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RECORD OF REVISIONS

Rev	Date	Description	POC	RM
0	06/28/99	Rewritten and reformatted to support LIR 220-03-01. Superseded Facilities Engineering Standards, Volume 7, Electrical, Manual Rev 15, 6/26/98.	David W. Powell, *PM-2*	Dennis McLain, *FWO-FE*
1	11/18/02	General revision and addition of endnotes. Replaces Subsections: 245.7, 271, 273, 274, and 275.	David W. Powell, *FWO-SEM*	Kurt A. Beckman, *FWO-SEM*
2	2/1/06	Updated refs to LANL Spec Sections, NEC, telecon stds, and LANL orgs; added telecon reqts for conference rooms, copy rooms and parking structures; updated reqts for admin access control system. Updated PTS and security system requirements; when Chapter 9 – Security is published, these reqts will be superceded. Indicated that fire alarm reqts will be superceded when the material appears in a rev of Chapter 2 – Fire Protection.	David W. Powell, *ENG-DECS*	Michael S. Harris, *ENG-DO*

D5030 COMMUNICATIONS

1.0 UNCLASSIFIED TELECOMMUNICATIONS SYSTEMS

1.1 Definitions[1]

A. **Backbone** is a facility (e.g., pathway, cable, or conductors) between telecommunications rooms, the entrance facilities, and the equipment rooms within buildings.

B. **Building core** is a three-dimensional space, permeating one or more floors, and is used for the extension and distribution of utility services (e.g., elevators, washrooms, stairwells, mechanical and electrical systems, and telecommunications) throughout the building.

C. **Category 5e** cable is 100 ohm twisted-pair copper cable that meets or exceeds specifications in ANSI/TIA/EIA-568-B.2, and is used for transmissions up to 100 MHz. The near-end crosstalk loss and return loss requirements are more severe than those of Category 5.

D. **Cross-connect** enables the mechanical termination and interconnection of premise cabling and backbone cabling.

E. **Entrance facility** is an entrance to a building for both public and private network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

F. **Equipment room** is a centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of its nature or complexity.

G. **Horizontal cable** extends from the telecommunications outlet/connector in the work area to the horizontal cross-connect in the telecommunications room.

H. **Pathway** is the vertical and horizontal route of the telecommunications cable.

I. **Telecommunications room** is an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and horizontal cabling.[2]

J. **Work area outlet** is a device placed at user workstation for termination of horizontal media and for connectivity of network equipment.

1.2 General

A. Design unclassified telecommunications (voice and data) system as described in this section and as required to meet the User's programmatic needs. Coordinate service and interior distribution requirements with the LANL Telecommunications Group.

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1 Definitions adapted from the BICSI Telecommunications Dictionary to suit conditions at LANL.
2 Refer to Chapter 3 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

B. Conform to the requirements of the latest editions of (and amendments to) the following telecommunications standards, the NEC, and this chapter of the LANL Engineering Manual:

1. TIA/EIA-568-B series, *Commercial Building Telecommunications Cabling Standard* (ANSI): [3, 4]
   - TIA/EIA-568-B.1 — General Requirements
   - TIA/EIA-568-B.2 —100-Ohm Balanced Twisted-Pair Cabling Standard
   - TIA/EIA-568-B.3 — Optical Fiber Cabling Component Standard
2. EIA/TIA-569-A, *Commercial Building Standard for Telecommunications Pathways and Spaces* (ANSI)[3] including Addendum 1 – Surface Raceways, Addendum 2 – Furniture Pathways and Spaces, and Addendum 3 – Access Floors.
3. EIA/TIA-606-A, *Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings* (ANSI). [3]
4. ANSI-J-STD 607-A, *Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications* (ANSI). [3]

C. Use the materials and installation methods described in LANL Construction Specifications Section 27 1000, *Structured Cabling*.

D. Install telecommunications system in accordance with NECA/BICSI 568, *Standard for Installing Commercial Building Telecommunications Systems* (ANSI).[5]

E. *Time and funding will be necessary for the installation of unclassified telecommunications system instruments and electronics, performance testing, and field quality assurance activities by the LANL Telecommunications Group. The Project should obtain a definitive cost estimate and schedule from the LANL Telecommunications Group.*

1.3 Telecommunications Rooms

A. Design telecommunications rooms that meet the requirements in EIA/TIA-569-A, the NEC, and this Chapter of the LANL Engineering Standards Manual.

B. Design dedicated lockable telecommunications rooms on each floor in new facilities and extensively remodeled facilities.[6]

1. *Very small buildings, with less than 10 work area outlets, may be provided with wall cabinets, or small closets instead of telecommunications rooms; coordinate requirements with the LANL Telecommunications Group.*[7]

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[3] The TIA/EIA telecommunications standards provide minimum requirements for wiring, pathways and spaces, grounding, and administration of telecommunications systems in commercial buildings. These standards were invoked for all federal buildings by FIPS PUB 174, 175, and 176. These documents are quite expensive and are not commonly available to designers. For this reason, applicable requirements from the TIA/EIA telecommunications standards are restated in this part of Chapter 7.

[4] The TIA/EIA-568-B series has replaced TIA/EIA-568-A dated October 6, 1995.

[5] The NECA *National Electrical Installation Standards* define a minimum baseline of Quality and workmanship for installing electrical products and systems. They are intended to be referenced in contract documents for electrical construction projects.

[6] Refer to §7.1 in TIA/EIA-569-A.

2. *For minor work in existing facilities, telecommunications system may be extended from existing telecommunications rooms if sufficient capacity exists; coordinate with the LANL Telecommunications Group.*

C. Refer to the layout for a typical telecommunications room on LANL Drawing ST-D5030-1.

D. Locate telecommunications room(s) to meet the following requirements:

1. Provide a minimum of one telecommunications room per floor.[8]
2. Provide additional telecommunications rooms when:[9]
   - Area served exceeds 10,000 sq. ft.
   - Horizontal cable will be more than 275 feet.[10]
3. Locate telecommunications room(s) in the building core.[11]
4. Locate the entrance room as close as practical to the main electrode ground bar.[12]
5. Locate the telecommunications entrance room above grade where it will not be flooded.[13]
6. In multi-story buildings align the telecommunications rooms vertically.[14]
7. Locate telecommunications rooms away from sources of electromagnetic interference such as power transformers, large motors, generators, x-ray equipment, radio or radar transmitters, arc welders, copiers, and induction heating equipment.[15]

E. Telecommunications rooms shall be dedicated to the telecommunications function and related support facilities.[16]

1. No electrical equipment or installations other than those for telecommunications shall be located in telecommunications rooms.
2. No equipment not related to the support of the telecommunications closet shall be installed in, pass through, or enter the telecommunications closet.
3. Servers must be installed in dedicated server rooms, not in telecommunications rooms.

F. Coordinate with the LANL Telecommunications Group on each project to properly locate and size the telecommunications room(s) to meet the requirements of the occupants of the building and the telecommunications equipment installers. Minimum telecommunications room dimensions[17] are as follows; room dimensions shall not be reduced without permission from the LANL Telecommunications Group:

1. Room serves less than 1000 sq. ft.: 6 ft X 3 ft. with double doors.

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7 Refer to Annex B.3 in TIA/EIA-569-A.
8 Refer to §7.2.2.1 in TIA/EIA-569-A
9 Refer to §7.1.2.1 in TIA/EIA-569-A
10 295 ft maximum in TIA/EIA-569-A §7.2.2.1.b) is decreased to allow for outlet relocation and/or use of extra long equipment cables.
11 Refer to §7.1.2 in TIA/EIA-569-A.
12 Refer to NEC Section 800.100(A)(4).
13 Refer to §8.2.1.3 and §8.3.2.1.4 in TIA/EIA-569-A.
14 Refer to figure 2.2-1 in TIA/EIA-569-A.
15 Refer to §8.2.1.5 in TIA/EIA-569-A.
16 Refer to §7.2.1 in TIA/EIA-569-A.
17 Refer to table §7.2.1 in TIA/EIA-569-A.

2. Room serves 1000 to 5,000 sq. ft: 10 ft X 7 ft.
3. Room serves up to 8,000 sq. ft: 10 ft X 9 ft.
4. Room serves up to 10,000 sq. ft: 10 ft X 11 ft.
5. Provide multiple closets on each floor that exceeds 10,000-sq. ft. or where the horizontal cable distance to the work area exceeds 275 ft.
6. *Entrance telecommunications rooms may need to be larger.*
7. If the telecommunications room supports secure communications, increase the size of the room to include one or more secure cabinets (each a minimum of 29" wide by 34" deep, verify with the LANL Telecommunications Group) with one meter clearance all around.

G. Design telecommunications rooms for a minimum distributed load of 100 lb./sq. ft. and a minimum concentrated load rating of at least 2000 lb.[18]

H. Provide wire cages for sprinkler heads to prevent accidental discharge.[19]

I. Design independent HVAC for telecommunications rooms larger than 20 sq. ft. with redundancy as required to maintain the following environmental conditions 24 hours per day, 365 days per year:[20]

1. Temperature: 64 ºF to 75 ºF
2. Relative Humidity: Non-condensing.
3. Positive pressurization with respect to adjacent spaces.
4. Minimum ventilation rate of one air change per hour.
5. Minimum 30 percent efficiency air filtration.
6. Heat from equipment installed in the telecommunications rooms will be approximately 2,500 BTU per equipment rack and a minimum of two racks per telecommunications room[21]; coordinate exact requirements with the LANL Telecommunications Group.

J. Line three walls of each telecommunications room with void-free 3/4-inch plywood, 8 ft high, that has been treated with two coats of white or light gray fire-retardant paint.[22]

K. Provide lighting with a dedicated switch for the telecommunications room.[23]

1. Provide a minimum illumination of 50 footcandles measured 3 ft. above the floor.
2. Locate the bottom of the lighting fixtures a minimum of 8′-6″ above the finished floor.
3. Orient lighting fixtures to optimize illumination of terminal blocks and equipment racks; coordinate with the LANL Telecommunications Group.

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18 Refer to §8.2.1.2 in TIA/EIA-569-A.
19 Refer to §7.2.6.3 in TIA/EIA-569-A.
20 Refer to §7.2.7 and §8.2.3.6 in TIA/EIA-569-A. Relative humidity requirement relaxed based on local operating experience and manufacturers' specifications for newer computing equipment. Filtration efficiency requirement added to reflect LANL ESM Chapter 6 requirements.
21 Criteria for equipment thermal loading provided by the LANL Telecommunications Group.
22 Refer to §7.2.4.1 in TIA/EIA-569-A.
23 Refer to §7.2.4.2 in TIA/EIA-569-A.

4. Provide lighting fixtures with lamp guards.

L. Install electrical receptacles in each telecommunications room as follows:[24]

1. Locate duplex receptacles spaced at 6 ft intervals around the perimeter of the room at 6 inches above the finished floor; serve by a dedicated 120 volt, 20 ampere circuit. These receptacles are for tools and test equipment.
2. For each equipment cabinet or rack, provide a 20 ampere, 120 volt, twist-lock, receptacle (NEMA L5-20R) on the cable tray above each equipment rack; serve each receptacle by a separate dedicated 20-ampere circuit. If available in the facility, use an isolated ground circuit with an isolated ground receptacle.
3. Provide two 2-circuit, multi-outlet assemblies in each room at 7'-6" above finished floor; verify locations with the LANL Telecommunications Group. Serve each multi-outlet assembly by two dedicated 20 ampere circuits for a total of four circuits. These multi-outlet assemblies are for wall mounted equipment. If available in the facility, use isolated ground circuits with isolated ground receptacles.

M. Locate the telecommunications ground bar at the rear corner of the left-hand wall in each telecommunications room, 12 inches above the floor. Refer to the "Telecommunications Grounding" heading below for additional grounding and bonding requirements in the telecommunications room.[25]

N. Install in each telecommunications room as described below and as shown in LANL Standard Drawing ST-D5030-1.

1. Install cable tray around the three interior walls of the telecommunications room and spanning across the middle of the room and above the equipment racks
2. Extend both ends of the cable tray into the corridor ceiling space; connect to the corridor cable tray system if present.
3. Locate the cable tray with bottom at 7′-9″ above the finished floor and edge of tray 8 inches from the backboard.[26]
4. Install wall-mounting brackets for the cable tray that do not reduce the useable area of the telecommunications board.
5. Provide not less than six cable tray dropout fittings in each telecommunications room; coordinate requirements with the LANL Telecommunications Group.
6. Provide an approved method to restore the fire rating of walls at cable tray penetrations; method must allow future installation and removal of cables.[27]

O. Design the telecommunications rooms with the following interior finish characteristics:

1. Minimum ceiling height: 12 inches above cable tray (a finished ceiling is not required).[28] Any fire resistive material that is applied to the structure must be sealed or covered to control dust that may contaminate electronic equipment.[29]

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24 Refer to §7.2.4.6 in TIA/EIA-569-A.
25 Refer to §7.2.4.7 in TIA/EIA-569-A.
26 Separation from terminal board is to allow vertical conduits to pass behind the cable tray.
27 Refer to §7.2.5 in TIA/EIA-569-A.
28 Refer to §7.2.4.3 in TIA/EIA-569-A.

2. Floor finished with vinyl tile.
3. Walls and ceiling (or exposed structure) finished with white paint to enhance lighting.[30]
4. Double 3′-0″ lockable doors that open outward into the building corridor.[31] For telecommunications rooms smaller than 20 sq. ft. provide double doors with top and bottom louvers.
5. Signage on the doors indicating the room number and "TELECOMMUNICATIONS - AUTHORIZED PERSONNEL ONLY."

P. *LANL will furnish and install cross connect equipment.*

1. *Cross connect for copper cables will consist of 8-pair termination blocks assembled on an interlinking mounting system with provisions for identifying cables.*
2. *Cross-connect equipment for fiber-optic cables will consist of patch panel racks.*

Q. Install fire stop material in telecommunications cable trays and raceways that penetrate fire-rated walls or floors.[32]

1.4 Server Equipment Rooms

A. Provide dedicated, lockable server equipment rooms in new or extensively remodeled office and/or laboratory facilities as required by the Users' programmatic needs.[33]

B. Design server equipment rooms to meet the requirements in EIA/TIA-569-A, NFPA 75, the NEC, and this Chapter of the LANL Engineering Standards Manual.

C. Select server equipment room locations with the following considerations:[34]

1. Avoid locations that are restricted by building components (elevators, stairwells, core facilities, etc.) that will limit future expansion of the server equipment room.
2. Design accessibility for the delivery of large equipment.
3. Locate server equipment room(s) as close as practical to the associated telecommunications room.
4. Locate server equipment rooms above grade where they will not be flooded.
5. Locate server equipment rooms away from sources of electromagnetic interference such as power transformers, large motors, generators, x-ray equipment, radio or radar transmitters, arc welders, copiers, and induction heating equipment.[35]

D. Server equipment rooms shall be dedicated to the telecommunications and computing functions and related support facilities.[36]

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29 Refer to §7.2.4.5 and §8.2.3.7 in TIA/EIA-569-A.
30 Refer to Chapter 7 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.
31 Refer to §7.2.6.1 in TIA/EIA-569-A.
32 Refer to NEC Section 300.21.
33 Refer to §8.1 in TIA/EIA-569-A.
34 Refer to §8.2.1 in TIA/EIA-569-A.
35 Refer to §8.2.1.5 in TIA/EIA-569-A.
36 Refer to §8.1.3 in TIA/EIA-569-A.

E. Coordinate with the LANL Telecommunications Group to properly locate and size the server equipment room(s) to meet the requirements of the occupants of the building. As an initial approximation, design server equipment rooms with useable floor areas as follows:

1. General office buildings: Use as a first approximation 0.75 sq. ft per 100 sq. ft of workspace area but a minimum server equipment room area of 150 sq. ft.[37]
2. Special-use buildings (laboratory, industrial, etc): 1 sq. ft per work area but a minimum server equipment room area of 150 sq. ft.[38]
3. Provide additional floor space in server equipment rooms for the following:
   - Bookshelves for software and equipment manuals.
   - Fireproof safe for software and back-ups.
   - HVAC equipment for server equipment room.
   - Electrical panelboard for server equipment.
   - Uninterruptible power supply (UPS) system for server equipment; however, any UPS larger than 100 kVA shall be in a separate room.

F. Design server equipment rooms for a minimum distributed load of 100 lb/sq. ft. and a minimum concentrated load rating of at least 2000 lb.[39]

G. Provide wire cages for sprinkler heads to prevent accidental discharge damage.[40]

H. Design independent HVAC for server rooms with redundancy as required to maintain the following environmental conditions 24 hours per day, 365 days per year:[41] *Server rooms located adjacent to telephone equipment rooms may share the same HVAC system.*

1. Temperature: 64 ºF to 75 ºF measured at 5 ft above the floor with all server and support equipment operating.
2. Relative Humidity: Non-condensing.
3. Positive pressurization with respect to adjacent spaces.
4. Minimum ventilation rate of one air change per hour.
5. Minimum 30 percent efficiency air filtration.
6. If a standby power source is available, connect server room HVAC to the standby supply.

I. Provide down-flow computer room AC units for server rooms with raised floors.

1. If multiple computer room AC units are used, locate on opposite walls.
2. Racks will be configured with “hot” and “cold” aisles.
3. Locate raised floor perforated air supply tiles only in “cold” aisles.

J. Provide lighting with a dedicated switch for the server equipment room.[42]

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37 Refer to §8.2.2.4 in TIA/EIA-569-A.
38 Refer to §8.2.2.4 in TIA/EIA-569-A.
39 Refer to §8.2.1.2 in TIA/EIA-569-A.
40 Refer to §8.2.3.5 in TIA/EIA-569-A.
41 Refer to §8.2.3.6 in TIA/EIA-569-A.

1. Design a minimum illumination of 50 footcandles measured 3 ft. above the finished floor in the middle of all aisles between equipment.
2. Do not supply lighting from the same panelboard that supplies the server equipment.

K. Provide general-purpose duplex receptacle outlets for tools and test equipment so no point measured horizontally on any wall space is more than 6 ft from a general-purpose receptacle outlet[43]; serve by dedicated 120-volt, 20-ampere general power circuit(s).

L. Provide a pushbutton at each of the exit door(s) from the room; connect pushbutton(s) to the electrical panelboard(s), UPS equipment, and HVAC equipment to disconnect power from electronic equipment and HVAC equipment in accordance with NFPA 75.

M. Provide a dedicated 208Y/120V isolated ground panelboard in the server equipment room to serve telecommunications equipment.[44]

1. As a first approximation, design for a power density of 100 VA per sq. ft.[45] Coordinate server room power requirements with the LANL Telecommunications Group
2. Provide power to the panelboard from an isolated ground power system separately derived through a shielded, k-rated transformer.[46] Refer to the "Lighting and Appliance Branch Circuit Panelboards" heading in Section D5010 of this Chapter.
3. Equip the panelboard with a surge protection device. Refer to the "Surge Protection" heading in Section D5010 of this Chapter for detailed requirements.
4. Equip the panelboard with a shunt trip connected to the power disconnect pushbutton(s) described above, to the fire alarm system, and to a two-stage thermostat in the server room. Design control system to cut all power to the room in case of either an over-temperature condition (100 ˚F) or smoke in the server room. Provide an audible alarm outside the server room that is triggered when an over-temperature condition in the server room is 10 ˚F less than the power cutoff point.
5. Provide isolated ground branch circuit wiring system to power server equipment; coordinate requirements with the LANL Telecommunications Group. Refer to Section D5020 of this Chapter for detailed requirements for branch circuit wiring systems.

N. If warranted by programmatic or operation need, provide UPS system(s) to support server equipment through momentary power anomalies and to an orderly programmed shutdown in case of an extended power interruption. Refer to Section D5090 for UPS requirements.

O. Locate a telecommunications ground bar adjacent to the electrical panelboard in each server equipment room, 12 inches above the floor. Refer to the "Telecommunications Grounding" heading below for additional grounding and bonding requirements in the server room.[47]

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42 Refer to §8.2.3.8 in TIA/EIA-569-A.

43 Receptacle spacing based on the 6-ft cords supplied with most power hand tools and test equipment. Adequate accessible receptacle outlets will reduce or eliminate the need for extension cords.

44 Refer to §8.2.3.9 in TIA/EIA-569-A. Relative humidity requirement relaxed based on local operating experience and manufacturers' specifications for newer computing equipment. Filtration efficiency requirement added to reflect LANL ESM Chapter 6 requirements.

45 Project experience at LANL: a 12-ft by 75-ft server room with a calculated electrical load of 88 kVA.

46 Recommended practice in IEEE Std. 1100-1999. Refer to §8.5.3.2 for a detailed description of the isolated ground power system as a means to reduce common-mode noise that may interfere with electronic telecommunications equipment.

P. Design pathway(s) for cables from the server racks to the corridor cable tray system and/or the associated telecommunications room.

1. If feasible, install an access floor system as described under the heading Telecommunications Horizontal Pathways. Provide minimum 12" raised floor to assure adequate cable routing space. If the server room exceeds 1000 sq. ft., provide minimum 18" raised floor.
2. If an access floor system is not feasible, install a cable tray system, as described under the heading Telecommunications Horizontal Pathways, above equipment racks with bottom of tray at 7′-9″ above the finished floor.[48]

Q. Design server equipment rooms with the following interior finish characteristics:

1. Minimum ceiling height: 12 inches above cable tray.
2. Floor finished with vinyl tile.
3. Walls and ceiling finished with light colors to enhance room lighting.[49]
4. Double 3′-0″ lockable doors, without doorsill, that open outward into a corridor.[50]
5. Badge reader access control.
6. Signage on the doors indicating the room number and "SERVER ROOM-AUTHORIZED PERSONNEL ONLY."

1.5 Telecommunications Grounding

A. Design telecommunications grounding to comply with TIA/EIA-607[51], *Commercial Building Grounding and Bonding Requirements for Telecommunications,* and the NEC.

B. Provide a telecommunications bonding backbone conductor that interconnects the telecommunications grounding busbar in each telecommunications room, each server equipment room, and each telecommunications equipment rack not located in a telecommunications room.[52] Use 4/0 AWG conductor with 600V insulation and connected with two-hole hydraulically compressed cable lugs.[53]

C. Provide a telecommunications main grounding busbar in the entrance telecommunications room, each "satellite" telecommunications room, each server equipment room, and at each telecommunications equipment rack not located in a dedicated room.[54]

1. Use a NEMA pattern (1.25 inch x 1.25 inch) pre-drilled electrotin-plated copper bar that is 1/4 inch thick, 4 inches wide, minimum 12 inches long plus additional length as

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47 Refer to §8.2.3.11 in TIA/EIA-569-A.
48 Telecommunications equipment racks are nominally 7 ft tall.
49 Refer to Chapter 7 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.
50 Refer to §7.2.6.1 in TIA/EIA-569-A.
51 ANSI-J-STD 607-A is the telecommunications standard that addresses grounding telecommunications grounding and bonding from a functional perspective. It is used in concert with ANSI/EIA/TIA-568 and ANSI/EIA/TIA-569.
52 Refer to §5.3 in ANSI-J-STD 607-A.
53 This is the same grounding conductor size and connection method used for electrical power systems at LANL. Used on telecommunications systems to simplify tooling and inspections.
54 Refer to §5.4 and §5.5 in ANSI-J-STD 607-A.

required to land the required cables plus at least 20% future growth. Mount busbar on 2-inch standoff insulators.

2. Bond the telecommunications main grounding busbar to the building electrical system main electrode ground bar using a dedicated 4/0 AWG conductor with 600V insulation and connected with two-hole hydraulically compressed cable lugs.[55]
3. Terminate the ground cable in telecommunications duct bank(s) to the ground bar in the entrance telecommunications room(s) using hydraulically compressed cable lugs.
4. If the building has a metal frame, also bond the busbar to the nearest structural steel using a 6 AWG conductor with crimp-on cable lugs.

D. Do not place grounding or bonding conductors in ferrous metallic conduit.[56]

E. Label, identify, and green color code each bonding and grounding conductor.[57]

F. Effectively ground and bond all metallic telecommunications raceways and cable trays.[58]

1. Bond the telecommunications cable tray to each telecommunications ground bar with minimum 6 AWG using crimp-on lugs.
2. Install a 6 AWG equipment grounding conductor in each cable tray and bond to every section using NRTL listed cable tray bonding clamps.[59]
3. Bond metal raceways entering the telecommunications room and containing telecommunications cables to the telecommunications ground bar.
   - Use 12 AWG conductor for individual conduits 1" and smaller.
   - Use 6 AWG conductor for multiple conduits or individual conduits larger than 1".
4. Connect metallic conduits to cable tray with approved cable tray to conduit clamps.
5. Isolated sections of metallic raceway or cable tray will be considered effectively grounded when clamped or bonded to the metal building structure.
6. In buildings without metal structure, install a minimum 12 AWG green insulated ground wire with the telecommunications cables to bond isolated sections of metallic raceway.

G. Use materials and installation methods described in LANL Construction Specification Section 26 0526, *Grounding and Bonding for Electrical Systems*.

1.6 Work Area Outlets

A. Provide work area outlets as follows: [60]

1. Two 4-port outlets in each private office, located on opposite walls. In spaces served by a protected transmission system (PTS), a PTS outlet will replace one of the work area

[55] Refer to §5.2 in ANSI-J-STD 607-A.
[56] Refer to §5.1.4 in ANSI-J-STD 607-A.
[57] Refer to §5.1.5 in ANSI-J-STD 607-A.
[58] Refer to NEC Section 250.96.
[59] Recommended practice in §8.4 of IEEE 1100-1999.
[60] Refer to §6.2.2 in TIA/EIA-569-A.

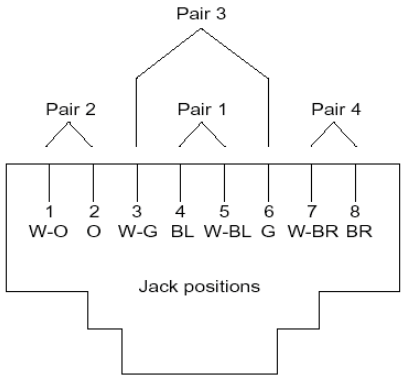
outlets and the other work area outlet will be a 6-port outlet; refer to the Protected Transmission System heading in this chapter.

2. Each open office workstation: one 4-port outlet.
3. Elevator equipment room for connection to elevator equipment: one 4-port outlet.
4. Main mechanical equipment room for building automation system: one 4-port outlet.
5. Main electrical room for electrical metering: one 4-port outlet within 4 ft of meter.
6. Each break room for a wall mounted telephone: one 4-port outlet.
7. Each badge reader for a wall mounted telephone: one 4-port outlet.
8. Each copy machine room: two 4-port outlets.
9. Each conference room: one 4-port outlet at the front of the room, one 4-port outlet in the floor centered in the room for teleconferencing.
10. Parking structures: one 1-port outlet outside each entry to each stairwell.
11. Provide additional work area outlets as required to meet the User's programmatic needs.

B. The LANL Telecommunications Group will provide the telecommunications outlet jacks. *The GFE outlet will typically consist of four RJ45 jacks on a common faceplate. Some projects will have fiber-optic connectors in place of some of the RJ45 jacks.*

C. Configure RJ45 jacks as T568B[61] per TIA/EIA-568-B; refer to Figure D5030-1.

Figure D5030-1: T568B Pin/Pair Assignments (front view of connector)



D. For each wall-mounted telecommunications outlet install 4-inch square, 2-1/8-inch[62] deep outlet box with single device raised cover.

E. Coordinate telecommunications outlet locations with furniture and equipment layout so outlets will be accessible.[63]

61 Pin/pair assignment with designation T868B is configuration used at LANL.
62 Refer to §4.4.4 in TIA/EIA-569-A.
63 Refer to §6.2.3 in TIA/EIA-569-A.

1. In common areas (e.g. conference rooms) install telecommunications outlets with center 18 inches above the finished floor.[64] Locate outlets to comply with Americans with Disabilities Act Accessibility Guidelines (ADAAG), 28 CFR Part 36, Appendix A.
2. Locate wall mounted and telecommunications outlets in hard wall-enclosed offices with center 7 inches above the finished floor (immediately above the cove base).[65, 66] Coordinate locations of outlets with modular furniture and associated hangers to assure that outlets will be accessible.[67]
3. Coordinate mounting height of outlets at lab benches and counters with architectural details. The maximum height to meet ADAAG requirements is 44 inches. [64]

F. Locate each telecommunications outlet within 3 ft of a suitable electrical power outlet; group and align power and communications outlets so a symmetrical appearance results.[68]

G. At the Fire Alarm Control Panel install a 6" x 6" x 4" box and a 3/4 inch conduit to the nearby telecommunications room.

1.7 Telecommunications Horizontal Pathways

A. Design telecommunications horizontal pathways meet the requirements in EIA/TIA-569-A, the NEC, and this Chapter of the LANL Engineering Manual.

B. Design telecommunications horizontal pathways to have the following characteristics:[69]

1. Suitable for all telecommunications media recognized in TIA/EIA-568-B.[70]
2. Allow at least four cable runs per telecommunications outlet.
3. Accommodate cabling changes.
4. Minimize occupant disruption when horizontal pathways are accessed.
5. Facilitate ongoing maintenance of horizontal cabling.
6. Accommodate future additions to and changes in cabling, equipment, and services
7. Provide for at least 20% future growth.

C. Use one or more of the following horizontal pathways to provide a telecommunications distribution system that is appropriate for the building use and strikes an acceptable balance between greatest flexibility and lowest life-cycle cost:[71]

1. Underfloor system (underfloor duct or cellular floor system)
2. Access floor

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64 Height complies with *ADA Accessibility Guidelines for Buildings and Facilities* (ADAAG), (28CFR, Ch 1, Part 36, App A) available at http://www.access-board.gov/adaag/html/adaag.htm.
65 Office spaces with special ADAAG accommodations will be provided on an as-needed basis.
66 The 7" center mounting height will allow the outlet device plate to be completely above a 4" cove base and below furniture "modesty panels" that are typically 9-1/4" AFF.
67 Lesson learned form LANL construction projects.
68 Refer to §6.2.3 in TIA/EIA-569-A.
69 Refer to Chapter 4 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.
70 Refer to §4.1.4 in TIA/EIA-569-A.
71 Refer to §4.1 in TIA/EIA-569-A.

3. Conduit
4. Cable tray
5. Wireway
6. Perimeter raceway
7. Furniture pathways.

D. Design underfloor pathway systems (underfloor duct or cellular floor system) to meet NEC requirements[72] and the design guidance in EIA/TIA-569-A.[73]

E. Design access floor pathway systems to meet NEC requirements,[74] the design guidance in EIA/TIA-569-A,[75] and the following requirements:

1. For general office areas, design the raised floor surface to be 8 inches high or higher.[76]
2. For computer or control room environments where the plenum is used for HVAC, design the finished floor to be 12 inches high or higher.[69]
3. Use cable trays, wireways, and dedicated routes so telecommunications cables in an access floor pathway can be placed in a manner that provides sufficient space for service personnel to stand on the structural floor without risk of damaging cable.[69]
4. Provide the following minimum clearances above and below cable trays and wireways[69]:
   - 2 inches of free space between the top of the wireway or the cable tray side rails and the underside of the stringers.
   - 1 inch of free space between the bottom of the wireway or the cable tray side rails and the structural floor for power conduits.

F. Use conduit pathway for individual telecommunications outlets and for furniture pathway/building interfaces. Provide conduit pathway systems that meet NEC requirements, the design guidance in EIA/TIA-569-A,[77] and the following requirements:

1. Install conduit runs with no more than 100 feet between pull points.[78]
2. Install conduit runs with no more than 180 degrees of bends between pull points. Install a pull box at any reverse bend.[79]
3. For conduits 2 inches and smaller the inside radius of conduit bends must not be less than 6 times the internal diameter of the conduit.[80] For conduits larger than 2 inches the inside radius of conduit bends must not be less than 10 times the internal diameter of the conduit. Do not use conduit bodies in any conduit pathway system.[69]

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72 Refer to NEC Articles 800.110.
73 Refer to §4.2 in TIA/EIA-569-A.
74 Refer to NEC Article 645.
75 Refer to §4.3 in TIA/EIA-569-A.
76 Refer to Chapter 4 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition. Although ANSI/TIA/EIA-569-A specifies 6 in as the minimum finished height for standard-height access floors, at least 8 in is necessary to provide sufficient space for cable trays and other means of cable management.
77 Refer to §4.4 in TIA/EIA-569-A.
78 Refer to §4.4.2.2 in TIA/EIA-569-A.
79 Refer to §4.4.2.3.1 in TIA/EIA-569-A.
80 Refer to §4.4.2.3.2 in TIA/EIA-569-A.

4. Select conduit sizes on the following basis:
   - Less than 50 ft between pulling points and only one bend: 40 percent fill.
   - More than 50 ft between pulling points or two 90-degree bends: 31 percent fill[81].
   - Minimum size: 1-inch unless specified otherwise
5. Install an individual 1-inch[82] conduit from each wall-mounted telecommunications outlet to a telecommunications cable tray or to the telecommunications room.
6. Install individual conduits from each furniture pathway/building interface to a telecommunications cable tray or to the telecommunications room. Size conduits based on 4 cables per workstation.
7. Terminate metallic telecommunications conduits using an insulated throat fitting or an insulating bushing.[83]
8. Use materials and installation methods described in LANL Construction Specifications Section 26 0533, *Raceways and Boxes for Electrical Systems*.

G. Use dedicated cable tray systems to distribute horizontal cables from the telecommunications room(s) to locations near the outlets.[84] Provide cable tray pathway systems that meet NEC requirements, the design guidance in EIA/TIA-569-A,[85] and the following criteria:

1. For general office buildings, size cable tray based on 1 sq. in. of cable tray per 100 sq. ft. of useable floor area served.[86]
2. Limit cable initial tray fill ratio to 41.6%.[87]
3. Provide and maintain not less than 12 inches access headroom above telecommunications cable trays.[88] *Careful design and installation coordination with the building structure, HVAC ductwork, sprinkler piping, and luminaires is required to maintain the required 12-inch clearance. Consider developing "plan and profile" type drawings for each cable tray to assure meeting this requirement.*
4. Use cable tray with a maximum rung spacing of 6 inches to reduce cable sag and the possibility of long-term cold creep insulation damage to telecommunications cables.
5. Do not install any wiring system other than telecommunications in any telecommunications cable tray.[69]
6. Refer to Section D5090 of this chapter for cable tray design requirements.

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81 Telecommunications cables are much more fragile than standard building wire. FPN No, 1 to Table 1 in Chapter 9 of the NEC states that for certain conditions a lesser conduit fill should be considered. Note 2 to Table 4.4-1 in TIA/EIA-569-A states that the number of cables that can be installed in a conduit is limited by the allowed maximum pulling tension of the cables.

82 Refer to table 4.4-1 in TIA/EIA-569-A. A 1-inch conduit provides capacity for up to six Category 5e 4-pair UTP plenum-rated cables.

83 Refer to §4.4.3.1 in TIA/EIA-569-A.

84 A cable tray concealed above corridor lift-out ceilings provides an economical and flexible way to accommodate evolving communications needs.

85 Refer to §4.5 in TIA/EIA-569-A.

86 Refer to §4.5.3 in TIA/EIA-569-A.

87 §4.5.3 in TIA/EIA-569-A sets an absolute maximum cable tray fill ratio of 50%. Limiting the initial fill ratio to 41.6% provides for 20% future growth.

88 Refer to §4.5.6 in TIA/EIA-569-A.

7. Use materials and installation methods described in LANL Construction Specifications Section 26 0536, *Cable Trays for Electrical Systems*.

H. Route horizontal pathways away from sources of electromagnetic interference such as electrical power wiring, radio frequency sources, power transformers, large motors and generators, induction heaters, arc welders, fluorescent and HID luminaires, etc.[89]

I. Identify horizontal pathways in accordance with EIA/TIA-606; generate records acceptable to the LANL Telecommunications Group.[90] Use materials and installation methods described in LANL Construction Specification Section 26 0553, *Identification for Electrical Systems*.

J. For retrofit of pathways for horizontal cables in existing buildings use materials and installation methods that comply with the NEC and meet TIA/EIA requirements.

1.8 Furniture Pathways

A. Comply with TIA/EIA-569-A Addendum 2 for furniture pathways.[91]

B. Comply with TIA/EIA-569-A section 10.3 "Separation from EMI Sources."

C. Provide separation from electric light and power conductors as required in NEC Article 800[92].

D. Use one of the two following options to obtain the required separation:

1. Metallic divider bonded to ground between power and telecommunications cables.
2. Dedicated separate pathway for telecommunications cables. *Guidance: Some furniture system manufacturers offer panel systems with a telecommunications pathway on top of the panels.*
3. Power conductors enclosed in grounded metallic raceway or cable sheath.

1.9 Backbone and Entrance Pathways

A. Provide a minimum of four 4-inch backbone pathway conduits interconnecting the vertically aligned telecommunications rooms in a building.[93]

B. Provide a minimum of one 4-inch backbone pathway conduit (or equivalent space in cable tray) interconnecting multiple telecommunications rooms on a floor.[94]

C. Provide a minimum of two telecommunications[95] entrance conduits (plus security[96] service entrance conduits as described under the heading "Physical Security System" in this section) from the entrance telecommunications room to the point of connection to the network;

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89 Refer to §10.3 in TIA/EIA-569-A.
90 Refer to Chapter 5 in TIA/EIA-606.
91 TIA/EIA-569-A Addendum 2 addresses furniture pathway planning, fill factors, capacity, access, bend radius, and power/telecommunications separation requirements.
92 Refer to NEC Section 800.133(a)(2).
93 Refer to §5.2.2.2 in TIA/EIA-569-A.
94 Refer to §7.2.2.2 in TIA/EIA-569-A.
95 Refer to §9.4.2.2 in TIA/EIA-569-A.
96 Argus security system requirement.

coordinate design for each project with the LANL Telecommunications Group. *Point of connection to the network will be either a maintenance hole (MH) or a telephone pedestal.*

1. Provide the number and size of entrance conduits based on the anticipated number and type of telecommunications circuits required in the building. *In office buildings, this anticipated number is often calculated as one entrance pair per 100 ft^2 of usable office space.* Coordinate with the LANL Telecommunications Group.
2. Table D5030-1 provides data for determining the quantity and size of underground entrance conduits.
3. Terminate the conduits in the left rear corner of the telecommunications room and adjacent to the left wall.[97]

Table D5030-1: Underground Entrance Conduits[98]

Telephone Entrance Pairs	Require
1-99	One 2-inch conduit plus 1 spare.
100-2000	Two 4-inch conduits plus 1 spare.
2001-3000	Three 4-inch conduits plus 1 spare.
3001-5000	Four 4-inch conduits plus 1 spare.
5001-7000	Five 4-inch conduits plus 1 spare.
7001-9000	Six 4-inch conduits plus 1 spare.

D. Route backbone and entrance pathways away from sources of electromagnetic interference such as electrical power wiring, radio frequency sources, power transformers, large motors and generators, induction heaters, arc welders, etc.[99] If pathways must be installed in close proximity (less than 24 inches) and parallel to potential sources of significant electromagnetic interference, use galvanized rigid steel conduit, intermediate metallic conduit (IMC) or similar raceway that will provide effective shielding.

E. Provide a woven polyester pull tape (1200-lb test) with stamped footage markings pulled into each backbone and entrance pathway conduit and all innerducts and tied off at each end.[100]

F. Seal the building end of each entrance pathway to prevent rodents, water, or gases from entering the building or MH. Use rubber conduit plugs or duct sealer, depending upon the conditions. Reseal conduits after cable is placed in them.[101]

G. Identify backbone and entrance pathways in accordance with EIA/TIA-606; generate records acceptable to the LANL Telecommunications Group.[90] Use materials and installation methods described in LANL Master Specification Section 26 0553, *Identification for Electrical Systems*.

97 Refer to LANL Standard Drawing ST-D5030-1.
98 Refer to Table 9.2 in Chapter 9 of the *BICSI Telecommunications Distribution Methods Manual*, 9th Edition.
99 Refer to §10.3 in TIA/EIA-569-A.
100 Footage markers facilitate ordering the correct length cable.
101 Refer to §5.1.1.2.8 in TIA/EIA-758.

1.10 Telecommunications Cables

A. Install four LANL-furnished horizontal cables[102] to each telecommunications outlet. Coordinate with the LANL Telecommunications Group to determine the exact types and mix of horizontal cables that will be provided.

1. *Copper horizontal cable will be UL listed as type CMP (plenum-rated), 4-pair, 24-gauge, Category 5e, unshielded twisted pair (UTP) cable with an outside diameter of approximately 0.24 inches.*[103]
2. *Fiber optic horizontal cable will be UL listed as type OFNP (plenum rated) cable with an outside diameter of approximately 0.24 inches.*[103]
3. The installing contractor shall terminate all Category 5e horizontal cables.
4. *LANL will terminate the fiber optic horizontal cables.*

B. Install LANL-furnished backbone cables to interconnect the telecommunications rooms and server equipment rooms. Coordinate with the LANL Telecommunications Group to determine the sizes, types, and mix of backbone cables that will be provided.

1. *Copper backbone cable will be ARMM (24 AWG) cable, UL listed as type CMR.*[103] *(Note that this cable is not plenum rated.)*
2. *Fiber optic backbone cable will be UL listed as type OFNR, tight-buffered fiber-optic cable with a mixture of single-mode and multi-mode fibers.*[103]
3. *LANL will terminate all backbone cables.*

C. Cable installers must have the following minimum qualifications:

1. Category 5e horizontal cables: BICSI Registered Installer Level 1 or equivalent certification; experience installing and terminating Category 5e cables on at least 2 previous projects.[104]
2. Fiber optic horizontal cables, all backbone cables: BICSI Registered Installer Level 2 or equivalent certification; experience installing backbone and fiber optic cables on at least 2 previous projects. [104]

D. Identify backbone cables, horizontal cables, and telecommunications outlets in accordance with EIA/TIA-606-A; generate records acceptable to the LANL Telecommunications Group.

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[102] The four ports on the work area outlet are for telephone, computer network interface, printer network interface, and spare.

[103] Cable information from the LANL Telecommunications Group.

[104] BICSI, a not-for-profit telecommunications association, is a worldwide resource for technical publications, training, conferences, and registration programs for low-voltage cabling distribution design and installation. BICSI is the only nationally recognized organization that offers a vendor independent comprehensive testing and registration program for both installers and designers. Installer registration is available at three levels: Installer Level 1 (minimum of six months experience), Installer Level 2 (minimum of two years experience) and Installer Technician Level (minimum of five years experience). Written and hands-on examinations must be successfully completed. Registration exams are offered at all levels. The required minimum work experience is necessary to sit for each exam. Successful completion of these exams reinforces and documents that BICSI registered installers have the background, knowledge, and skills needed to work effectively.

E. Test the installed and terminated Category 5e horizontal cables in accordance with TIA/EIA-568-B; provide test results for each cable to the LANL Telecommunications Group. The LANL Telecommunications Group may spot-check test results.

2.0 PROTECTED TRANSMISSION SYSTEM (PTS) (SUPERSEDED BY ESM CHAPTER 9 WHEN ISSUED)

2.1 General

A. Design protected transmission system (PTS) as described in this section as required to meet the Users' secure communications needs in LANL facilities.

B. Conform to the requirements of the latest editions of (and amendments to) the TIA/EIA standards referenced for unclassified telecommunications systems[105], the NEC, DOE M 200.1-1—*Telecommunications Security Manual*, the LANL PTS Master Plan, and this chapter of the LANL Engineering Standards Manual. (The use of the "For Official Use Only" document DOE M 200.1-1 and the PTS Master Plan will be coordinated through the LANL PTS Site Manager.)

C. Coordinate PTS design requirements with the LANL PTS Site Manager.

D. Before beginning PTS construction obtain approval of the design drawings and the "Protected Transmission Systems CDIN/PTS Security Plan Request for Access to a Secure Communications Utility" from the LANL PTS Site Manager.

1. The construction contractor will furnish and install the PTS pathway system.
2. LANL will perform a technical inspection of the PTS pathway system.
3. LANL will furnish for construction contractor installation the PTS cables and terminal connection boxes.
4. LANL will furnish and install the PTS patch panels and terminal connection devices.
5. LANL will install connectors then will terminate and test all PTS cables.

E. After construction of the PTS, detailed "as built" drawings showing outlets, routing of pathways, junction boxes and pull boxes must be submitted to the LANL PTS Site Manager prior to activation approval.

F. *Time and funding will necessary for the inspection of PTS pathways, installation of PTS outlets and electronics, performance testing, and field quality assurance activities by LANL. The Project should obtain a definitive cost estimate and schedule from the LANL PTS Site Manager.*

G. Refer to LANL Master Specification Section 27 1500, *Protected Transmission System Rough-in* for PTS material and installation requirements.

[105] TIA and EIA telecommunications standards are useful because PTS systems are fundamentally telecommunications systems.

2.2 Definitions[106]

A. **CDIN:** The abbreviation for "classified distributive information network" that is any cable, wire, or other approved transmission media used for the clear text transmission of classified information in certain DOE controlled access environments. Excluded is any system used solely for the clear text transmission and reception of intrusion/fire alarms or control signaling.

B. **CDIN-1:** A type of CDIN used in a Limited Area.

C. **CDIN-2:** A type of CDIN used in a Property Protection Area.

D. **Limited Area:** A DOE or DOE contractor controlled space or facility in which all personnel who have unescorted access possess a final government issued security clearance or are under continuous escort by properly trained persons possessing a final security clearance.

E. **Property Protection Area:** A DOE or DOE contractor controlled space or facility in which all non-cleared personnel have unescorted access but must pass through a visitor control process to enter. The visitor control process must include identifying and recording the visitor and verifying the validity of the visit.

F. **PTS:** The abbreviation for protected transmission system. A term used to describe an approved data communications system that provides adequate physical safeguards to permit its use for the transmission of unencrypted classified information.

G. **RED:** Designation applied to information systems and associated areas, circuits, components and equipment in which National Security Information (classified) is processed. (BLACK is the designation applied to information systems and associated areas, circuits, components and equipment in which National Security Information is not processed (unclassified). Encrypted signals are unclassified.)

H. **Terminal Connection:** A term used at LANL to refer to the point where the user connects to the secure communications utility (personal computer interface). Terminal connections are commonly referred to as "drops." The connection is also often referred to as a Protected Outlet Box (POB).

2.3 PTS Topology

A. In large facilities (larger than about 25,000-sq. ft.) design a system of dedicated secure (RED) telecommunications rooms for terminating PTS entrance pathways, PTS backbone pathways, and PTS horizontal pathways. Provide secure (RED) server rooms that are connected to the RED telecommunications rooms by PTS backbone pathways.

B. In a smaller facilities use the RED server room as the termination point for PTS entrance pathways and PTS horizontal pathways.

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[106] Definitions from DOE M 200.1-1, *Telecommunications Security Manual*, as adopted for LANL use in the "Los Alamos National Laboratory Protected Transmission System (PTS) Master Plan" dated March 7, 2002.

2.4 RED Telecommunications Rooms

A. Design dedicated RED telecommunications room(s) that meet relevant requirements described for unclassified telecommunications rooms plus the following requirements:

1. Provide RED telecommunications room(s) in addition to the unclassified telecommunications room(s). If possible, locate the RED telecommunications room(s) adjacent to the unclassified telecommunications room(s).
2. Locate RED telecommunications room(s) in the secure part(s) of the building.
3. Increase the size of the RED telecommunication room(s) to accommodate one or more RED patch panel racks (each a minimum of 29" wide by 34" deep) and to provide not less than the required RED/BLACK separation from BLACK equipment, signal/data lines, power lines, and "fortuitous conductors." RED/BLACK separation requirements depend upon the PTS transmission media. Obtain RED/BLACK separation requirements from the LANL PTS Site Manager.

2.5 RED Server Equipment Room(s)

A. Design dedicated, RED server equipment room(s) as required to meet the Users' programmatic needs. *RED server rooms are often designated as "vault-type rooms" having special security system requirements—refer to the Security Systems heading in D5030.*

B. Design RED server room(s) to meet requirements for unclassified telecommunications server rooms plus the following additional requirements:

1. Locate RED server room(s) within the secure part(s) of the building.
2. Locate RED server rooms adjacent to RED telecommunications rooms (if used).
3. Provide not less than the required RED/BLACK separation from BLACK equipment, signal/data lines, power lines, and "fortuitous conductors." RED/BLACK separation requirements depend upon the PTS transmission media. Obtain RED/BLACK separation requirements from the LANL PTS Site Manager.

2.6 PTS Terminal Connections

A. Each PTS terminal connection will consist of a LANL-furnished surface-mounted box with LANL-furnished and installed fiber-optic connectors.

B. Position each PTS terminal connection at a readily accessible location 42 inches above the floor. *PTS terminal connection should be located at least 30 inches from corner of room to prevent being blocked by furnishings.*

2.7 PTS Horizontal Pathways

A. Design PTS horizontal pathway systems to meet applicable requirements in EIA/TIA-569-A, the NEC, DOE M 200.1-1, the LANL PTS Master Plan, and this Chapter of the LANL Engineering Manual.

B. In Limited Areas provide PTS horizontal pathways as follows: [107]

1. Exposed: CDIN-1.
2. Above easily accessible ceilings or below an easily accessible floor: CDIN-1. *Note that an unexposed CDIN must receive visual and technical inspections more frequently than an exposed CDIN. The User should evaluate this stream of future costs compared to the aesthetic benefits of concealing the CDIN.* Approval for unexposed CDIN must be obtained on a case-by-case basis from the LANL PTS Site Manager.

C. In Property Protection Areas design PTS horizontal pathways as follows: CDIN-2.[107]

D. PTS pathways shall not be installed in the public domain (Uncontrolled Access Areas) at LANL.[108]

E. Physical requirements for CDIN-1 pathways are as follows: [107]

1. Use conduits, wireways, ducts, and boxes made of ferrous material; use Intermediate Metal Conduit IMC).
2. Secure covers for boxes with tamper-resistant fasteners. Secure wireway covers with tamper-resistant fasteners placed at each end of each cover.[109]
3. Position pathways with respect to mechanical equipment, ductwork, piping, and fixed architectural finishes so the pathways will be continuously inspectable.
4. RED/BLACK separations between CDIN pathways and other system raceways or cables are dependent upon the PTS transmission media. Obtain RED/BLACK pathway separation requirements from the LANL PTS Site Manager.

F. CDIN-2 pathways must meet CDIN-1 requirements plus all joints, connections, cracks, seams, doors, etc. must be sealed with a properly administered tamper-indicating seal approved by DOE. *Welding or conductive epoxy may also be used at the discretion of the cognizant DOE office.* [107]

G. PTS pathways must pass a comprehensive technical inspection by the LANL PTS Site Manager. [108]

H. Use NRTL listed metal wireways to distribute multiple PTS cables from RED patch panel racks to the vicinity of the PTS terminal connections. Wireway systems must meet the appropriate CDIN requirements and the following criteria:

1. Size raceway based on one cable per terminal connection.[110]
2. Cable outside diameter approximately 0.25".[103]
3. Provide for 20% future growth in the number of PTS cables.

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[107] Refer to Chapter 5 in DOE M 200.1-1.

[108] Refer to the "Los Alamos National Laboratory Protected Transmission System (PTS) Master Plan" dated March 7, 2002.

[109] Tamper-resistant fasteners required by the "Los Alamos National Laboratory Protected Transmission System (PTS) Master Plan" dated March 7, 2002.

[110] Typical configuration is called "KVM"; the user's computer is in the RED server room and is connected via the PTS to a keyboard, video display, and mouse at the terminal connection in the workspace.

4. Initial wireway fill shall not to exceed the following values:
   - 41.7% of the wireway cross section area if there are no current-carrying electrical conductors in the wireway.[111]
   - 16.7% of the wireway cross section area if there is any current-carrying electrical conductor in the wireway.[112]
5. Locate PTS wireways with sufficient space to permit access for installing and maintaining cables and for security inspections. [88] *Careful design and installation coordination with the building structure, HVAC ductwork, sprinkler piping, and luminaires is required to maintain the required access. Consider developing "plan and profile" type drawings for each PTS wireway to assure meeting this requirement.*
6. Refer to Section 27 1500, *Protected Transmission System Rough-in* for wireway material and installation requirements.

I. Provide an individual 1-inch IMC from PTS wireway to each PTS terminal connection. Design conduit system to meet the appropriate CDIN requirements. Refer to Section 27 1500, *Protected Transmission System Rough-in* for conduit material and installation requirements.

2.8 PTS Backbone and Entrance Pathways

A. For large buildings provide the following secure backbone and entrance pathways:
   1. Provide a minimum of two 4-inch CDIN conduits interconnecting secure patch panel racks in the vertically aligned secure telecommunications rooms in a building.[113]
   2. Provide a minimum of one 4-inch CDIN conduit interconnecting secure equipment racks in multiple secure telecommunications rooms or secure server rooms on a floor.[114]
   3. Provide an underground ductbank with a minimum of two 4-inch ducts from the point of connection to the network (telephone manhole or telephone pedestal as directed by LANL Telecommunications Group) into the entrance secure telecommunications closet.[115] Terminate PTS entrance conduits in a 24" x 24" x 12" hinged cover box.

B. For small buildings install an underground ductbank with a minimum of two 4-inch ducts from the point of connection to the network (telephone manhole or telephone pedestal as directed by LANL Telecommunications Group) into secure server equipment room.[116] Terminate the conduits in the secure equipment rack.

C. Maintain not less than 6 inches separation between PTS entrance conduits and any other utility. Encase conduits for SRD systems in concrete providing not less than 3 inches coverage on all sides. Encase conduits for TSRD systems in concrete providing not less than 8 inches coverage on all sides. Place the top of the ductbank not less than 3 feet below

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111 NEC Section 770.12 removes raceway fill limitations if there are no current-carrying conductors; however, clause 4.5.3 in TIA/EIA-569-A sets an absolute maximum wireway fill ratio of 50%. Limiting the initial fill ratio to 41.6% provides for 20% future growth.

112 Refer to NEC Sections 770.12 and 376.22. Section 376.22 limits wireway fill to 20%. Limiting the initial fill ratio to 16.7% provides for 20% future growth.

113 Refer to §5.2.2.2 in TIA/EIA-569-A.

114 Refer to §7.2.2.2 in TIA/EIA-569-A.

115 Refer to §9.4.2.2 in TIA/EIA-569-A.

116 Refer to §9.4.2.2 in TIA/EIA-569-A.

finished grade.[117] Identify the PTS entrance conduits with red spray paint placed 3-ft on centers.

D. Use materials and installation methods described in LANL Construction Specification Section 26 0533, *Raceways and Boxes for Electrical Systems* and Section 33 7119, *Electrical Underground Ducts and Manholes*.

E. PTS ductbanks must pass a comprehensive visual inspection by the PTS Site Manager before being covered.

F. Coordinate requirements with the LANL PTS Site Manager.

2.9 PTS Cables

A. LANL will provide one GFE horizontal PTS cable for each terminal connection. Coordinate with the LANL PTS Site Manager to verify the type of cable.

1. GFE PTS horizontal cable typically consists of multiple tight-buffered multi-mode fibers; cable outside diameter is approximately 0.25 inches. [103]
2. *LANL will connectorize, terminate, and test the PTS horizontal cables at both ends.*

B. LANL will provide GFE backbone PTS cables to interconnect the secure telecommunications rooms. Coordinate with the LANL PTS Site Manager to determine the sizes, types, and mix of CDIN backbone cables.

1. CDIN fiber optic backbone cable will be UL listed as type OFNR, tight-buffered fiber-optic cable with a mixture of single-mode and multi-mode fibers. [103]
2. *LANL will connectorize, terminate, and test the PTS backbone cables at both ends.*

C. Cable installers must have BICSI Registered Installer Level 2 or equivalent certification. [104]

2.10 Identification

A. Identify PTS terminal connection boxes in accordance with EIA/TIA-606-A; generate records acceptable to the LANL PTS Site Manager.

B. Band CDIN raceways with 3/4-inch wide red plastic tape on 3-ft centers. Start bands 2 inches from the protected outlet boxes.

C. Identify each PTS pathway and cable in accordance with EIA/TIA-606-A; generate records acceptable to the LANL PTS Site Manager.[90] Use materials and installation methods described in LANL Construction Specification Section 26 0553, *Identification for Electrical Systems*.

[117] Requirements for Protected Distribution Systems in Chapter 5 of DOE M 200.1-1 are extended to the entrance conduits.

3.0 VOICE PAGING SYSTEMS

3.1 General

A. Design an overhead voice paging system throughout each facility as required to meet the User's programmatic needs.[118] Coordinate with the LANL Telecommunications Group.

B. Locate speakers in all occupied spaces including corridors, offices, laboratories, shops, warehouses, conference rooms, copy rooms, file rooms, break rooms, restrooms, mechanical rooms, electrical rooms, and telecommunications rooms.[119]

C. Conform to the requirements of the NEC[120], and the LANL Engineering Standards Manual.

D. Voice paging systems shall include the following components:

1. Speakers
2. Speaker wiring.
3. Terminal box(es)
4. Zone paging amplifier(s) (furnished by the LANL Telecommunications Group).
5. Page controller(s) (furnished by the LANL Telecommunications Group).

E. Life safety[121], noise masking[122], and sound reinforcement[123] are beyond the scope of this heading. *Voice evacuation systems (such systems will meet the requirements of NFPA 72 or 29CFR 1910.165--"Employee Alarm Systems" and will use equipment that is NRTL-listed to UL Standard 864) may be used as the basis for the paging system described in this section.*

F. Design an overhead voice paging system that is accessible from telephones in the building by dialing an access code, either for a particular zone or for "all-call."[124]

G. Zone the system by floor, by function, or by organization; refer to Figure D5030-2. Provide one or more amplifiers for each zone; wire speakers in each zone to a specific amplifier. [124]

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118 Overhead voice paging systems facilitate locating personnel, alerting occupants to changes in operating status, etc. The system provides the users with the capability to use their telephone to access the voice-paging speakers that are typically mounted in the ceiling. In large buildings, zones can be individually accessed or dialing the "all zones" code can access the entire building.

119 The intent is to provide full coverage of the building, including service spaces.

120 Refer to NEC Articles 640 and 725.

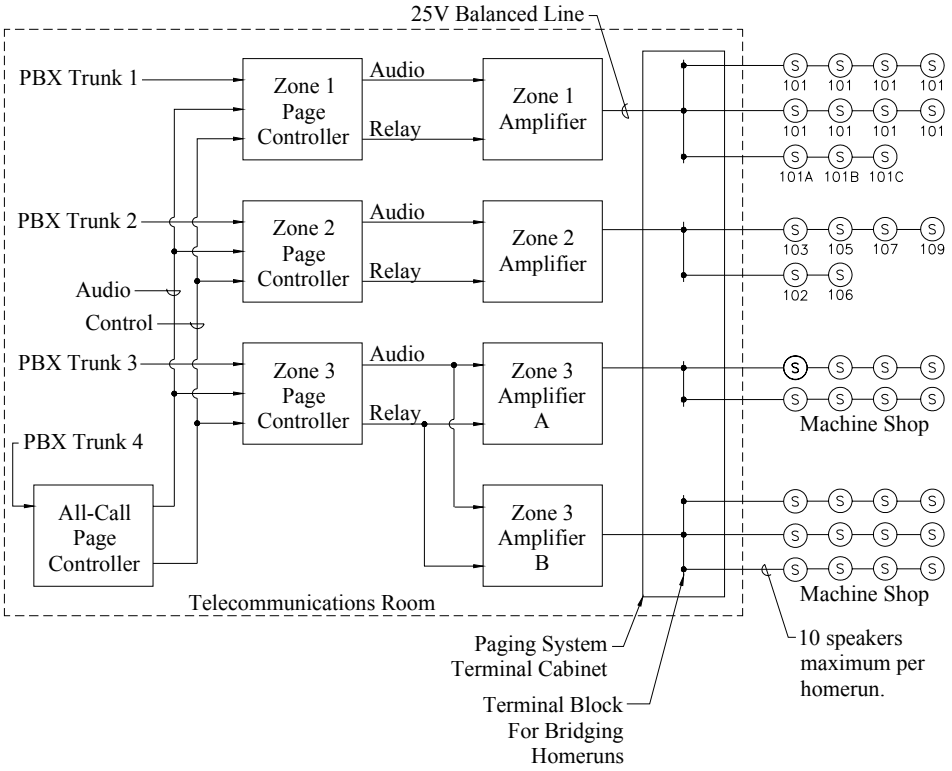
121 The purpose of a "life safety" system is to announce to one or more zones that there is a potential life safety concern. The most common use of this system is to announce to the building occupants that they should evacuate the building due to a fire or other dangerous situation. The design and installation of life safety systems must conform to ANSI/NFPA 72, *National Fire Alarm Code.*

122 Noise masking systems are often used in open office applications and generate "white noise" to create an artificial sound barrier.

123 Sound reinforcement systems are typically used in auditoriums and theaters to increase the loudness of the person speaking or to play pre-recorded music.

124 Refer to Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

Figure D5030-2: Typical Zoned Paging System



H. Provide separate zones with separate conduits, cables, and amplifiers for secure areas.

I. *Time and funding will be necessary for the installation of paging system electronics, performance testing, and field quality assurance activities by the LANL Telecommunications Group. The Project should obtain a definitive cost estimate and schedule from the LANL Telecommunications Group.*

J. Refer to LANL Specification Section 27 5113, *Paging Systems* for materials and installation requirements.

3.2 Design Parameters

A. Design a distributed speaker system that gives even coverage for each space at the lowest sound power level (SPL) possible but at least 6 dB above the ambient noise level.[125]

B. In order to plan the type, number, and placement of speakers, determine the ambient noise level of each area under consideration.

[125] Refer to Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition. Keep the level of the reproduced direct sound level as low as possible so that the reverberant sound is not audible. Direct sound is sound that travels directly from a speaker to the listener. Reverberant sound is sound that is reflected from a surface such as a wall or floor to the listener. A high level of reverberant sound could cause the direct sound to be unintelligible.

1. In a new facility where only blueprints are available, use Table D5030-2 to estimate ambient noise levels.

Table D5030-2[126]

Typical Ambient Noise Levels	
Location	**dB**
Machine Shop	90
Mechanical Room	85
Assembly line	75
Lab or noisy office	70
Public corridor	65
Office (quiet)	55

2. In an existing facility, perform on-site testing with a sound level meter. Measure ambient noise levels at peak periods using the "A" weighting scale on the sound level meter.[127]

C. In office and laboratory environments provide ceiling recessed speakers distributed in corridors, offices, conference rooms, laboratories, copy rooms, file rooms, break rooms, restrooms, equipment rooms and similar spaces. [124]

D. In high noise areas provide horn speakers to direct the sound toward the listener and away from areas, such as walls, that may cause reverberant sound to occur. [124]

3.3 Speaker Placement

A. Place speakers to provide uniform coverage of each area. [124]

1. *For cone-type ceiling-mounted speakers the two most common speaker distribution patterns are a "hexagonal pattern" and a "square pattern." A "hexagonal pattern" is preferred because it provides the most uniform coverage.*

2. *For horn-type speakers the preferred placement is a "diamond pattern" with all horns pointing the same direction.*

B. In areas with less than 70-dB noise level, locate 8-inch ceiling-mounted speakers so the distance between speakers is approximately twice the ceiling height. Use Table 5030-3 to determine speaker density. Design the distribution system based on 0.5 watt per speaker in quiet areas (less than 65 dB) and 1 watt per speaker in noisy areas (up to 70 dB). [124]

[126] Based on Table 23.1 in Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

[127] The "A" weighting scale is designed to correspond to the sensitivity of the human ear at various frequencies; refer to ASA S1.1 for a more detailed definition.

Table 5030-3[128]

Ceiling Speaker Coverage (Maximum 70-dB Noise Level)				
Quantity of Speakers	**8 ft Ceiling Height**	**9 ft Ceiling Height**	**10 ft Ceiling Height**	**12 ft Ceiling Height**
1	250	325	400	574
2	500	650	800	1148
3	750	975	1200	1722
4	1000	1300	1600	2296
5	1250	1625	2000	2870
6	1500	1950	2400	3444
7	1750	2275	2800	4018
8	2000	2600	3200	4592
9	2250	2925	3600	5166
10	2500	3250	4000	5740

Decrease the distance between speakers in areas with a noise level greater than 70 dB.

C. Provide increased speaker density in corridors to reduce reverberation.

1. For typical enclosed corridors, locate ceiling-mounted cone-type speakers along the center of the corridor at approximately 8-ft intervals. Place the first speaker approximately 6-ft from the end of the corridor and work toward the other end. Place a ceiling speaker at each corridor junction. Design the distribution system based on 0.5 watts per speaker. [124]
2. Where ceiling speakers cannot be used, use wall-mounted bi-directional cone-type speakers placed at intervals of approximately 25 ft on alternating sides of the corridor. Place the first bi-directional speaker 20 feet from the end of the corridor and work toward the other end. Design the distribution system based on 1 watt per speaker. [124]

D. Use horn speakers having a directional projection pattern in industrial environments with more than 70-dB ambient noise, outdoors, or where each speaker must cover a large area. [124] Use Table 5030-4 to determine the area coverage for one 15 W horn mounted 16 ft above the floor and adjusted to a 60-degree angle of projection under given ambient noise levels.

Table 5030-4[129]

Coverage for 15W Horn Speaker	
SPL of Ambient Noise	**Area**
Up to 74 dB	4000 sq. ft.
75 to 89 dB	2500 sq. ft.
90 dB and above	1200 sq. ft.

E. Coordinate speaker locations with luminaires, HVAC, sprinklers, and architectural finishes.

[128] Based on Table 23.2 in Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.
[129] Based on Table 23.3 in Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*.

F. To protect against feedback, do not locate ceiling speakers directly above telephone sets or external microphones. [124]

3.4 Speaker Wiring

A. Use a 25-volt constant voltage system to distribute audio signals to paging speakers.[130]

B. Size distribution system conductors to limit line loss to 10% based on the total wattage of all speakers on the line [124] plus an allowance for 20% future system growth. Use Table D5030-5 to select conductor sizes based on line length and signal strength.

Table D5030-5: 25V Speaker Line Loss[131]

25V Audio Line 0.5dB (10%) Loss		Wire Gauge >			18 AWG	16 AWG	14 AWG	12 AWG	10 AWG
		Max Current (A) >			10	13	15	20	30
		Resistance (ohms/kFT)>			7.95	4.99	3.14	1.98	1.24
Load Power (W)	Input Power (W)	Line Loss (W)	Line Current (A)	Line Res. (ohms)	Maximum Distance (ft)				
250	277.8	27.78	11.11	0.23	---	23	36	57	91
200	222.2	22.22	8.89	0.28	18	28	45	71	113
150	166.7	16.67	6.67	0.38	24	38	60	95	151
100	111.1	11.11	4.44	0.56	35	56	90	142	227
75	83.3	8.33	3.33	0.75	47	75	119	189	302
60	66.7	6.67	2.67	0.94	59	94	149	237	378
50	55.6	5.56	2.22	1.13	71	113	179	284	454
40	44.4	4.44	1.78	1.41	88	141	224	355	567
25	27.8	2.78	1.11	2.25	142	225	358	568	907
20	22.2	2.22	0.89	2.81	177	282	448	710	1134
15	16.7	1.67	0.67	3.75	236	376	597	947	1512
10	11.1	1.11	0.44	5.63	354	564	896	1420	2268
7.5	8.3	0.83	0.33	7.50	472	752	1194	1894	3024
5	5.6	0.56	0.22	11.25	708	1127	1791	2841	4536
4	4.4	0.44	0.18	14.06	884	1409	2239	3551	5670
2.5	2.8	0.28	0.11	22.50	1415	2255	3583	5682	9073
2	2.2	0.22	0.09	28.13	1769	2818	4479	7102	11341
1	1.1	0.11	0.04	56.25	3538	5636	8957	14205	22681

130 The direct current (dc) resistance of the pair of wires that feed each speaker can consume a high percentage of the power from the amplifier. To avoid this power loss a larger gauge of wire could be used. This does add more cost to the project. A more efficient way to overcome the effects of the wire's dc resistance is to operate the system at a raised voltage and a reduced current. This type of system is called a constant voltage system because the amplifier delivers an almost constant voltage to the distribution lines regardless of the number of speakers connected to the line. With this system, speakers can be added or removed from the system with no noticeable change in system loudness. There are two systems in general use: 70-volt and 25-volt. 25-volt systems are used at LANL so communications technicians can work on the systems and comply with LIR402-600-01, *Electrical Safety*.

131 Based on Figure 23.3 in Chapter 23 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition, converted from 70.7v to 25v and changed into a table.

C. Use twisted-pair speaker cables configured as balanced lines.[132] Refer to LANL Specification Section 27 5113, *Paging Systems* for materials and installation requirements.

D. Use multi-tap impedance-matching transformers to convert the 25-volt line signal to the 8-ohm speaker impedance. [124]

E. Uniquely identify each end of each speaker cable; generate cable records acceptable to the LANL Telecommunications Group.[133] Use materials and installation methods described in LANL Specification Section 26 0553, *Identification for Electrical Systems*.

3.5 Speaker Raceways and Enclosures

A. For new construction install speaker cables in raceway systems dedicated to speaker cables.[134]

1. Use flexible metal conduit to connect to speakers mounted in accessible ceilings.
2. Use methods and materials described in LANL Construction Specification Section 27 513, *Paging Systems* for materials and installation requirements.
3. Make paging system raceways electrically continuous. Bond all paging system raceways to the telecommunications ground bar.

B. For retrofit of paging systems in existing facilities use materials and installation methods that comply with NEC and TIA/EIA requirements. Avoid placing speaker wiring in close proximity to telecommunications horizontal cables.

C. Install a wall-mounted 24” x 24” x 6” hinged cover cabinet below the cable tray and near the paging system equipment rack(s) in the telecommunications closet(s). Coordinate cabinet location with the LANL Telecommunications Group. Terminate the speaker conduits into the cabinet. Install terminal blocks in the cabinet for connecting and bridging speaker cables.

D. Install ceiling-mounted cone-type speakers in metal backboxes with round perforated face metal baffles.

3.6 Paging Amplifiers (Furnished by the LANL Telecommunications Group)

A. Base the power rating of each paging zone amplifier on: [124]

1. The total sum of the tap watts of each impedance matching transformer on each speaker.
2. The total sum of the power lost in the speaker distribution cabling.
3. Power reserved for 20 percent future growth.

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[132] Balanced lines are recommended for installations where speaker lines and other lines that carry electric current (e.g., telephone, radio frequency [RF], alternating current [ac] power) run parallel and close to each other. In these installations, the signals in one set of lines may be picked up by another line, causing hum, noise, or crosstalk. Balanced lines help eliminate or reduce induced noise because induced signals have the same polarity in both lines (e.g., the noise currents flow in the same direction in both lines). If these signals arrive at the load in opposition to each other and at equal amplitude, they will cancel each other out.

[133] Adequate identification and records of cables will facilitate set-up, troubleshooting, and additions to the paging system.

[134] Raceway systems provide support and protection for the paging system cables.

4. Add to this number an additional 25 percent so that the amplifier will normally be operating at about 75 percent of its rated output.

B. Locate paging equipment in one or more of the telecommunications rooms. Design suitable equipment rack(s) to house amplifiers and page controllers.

3.7 Acceptance Testing

A. Perform acceptance testing using the following procedure: [124]

1. Adjust the amplifier to 75 percent of the rated power.
2. Select an area to measure and use a sound level meter to measure the ambient noise level.
3. Broadcast a message over the system that is representative of a normal voice page.
4. Measure the SPL of the voice page. The SPL of the voice page must be at least 6 dB higher than the ambient noise.
5. Measure the SPL in all areas within the system.
6. Adjust individual speakers by changing taps on the impedance matching transformers.

4.0 CATV (LABNET) SYSTEMS

4.1 General

A. Design cable television (LABNET) distribution system to meet the Users' functional and operational requirements. Coordinate service and interior distribution requirements with the LANL Telecommunications Group.

B. Conform to the requirements of the NEC and this chapter of the LANL Engineering Manual.

C. The LANL Telecommunications Group will furnish internal coaxial cable, connectors, directional couplers (splitters), taps, and outlets as GFE.

D. Entrance coaxial or optical fiber cable, and CATV head-end electronics will be furnished and installed in the entrance telecommunications room by the LANL Telecommunications Group.

E. *Time and funding will be necessary for the installation of CATV electronics, performance testing, and field quality assurance activities by the LANL Telecommunications Group. The Project should obtain a definitive cost estimate and schedule from the LANL Telecommunications Group.*

F. Use the materials and installation methods described in LANL Construction Specifications Section 27 1000, *Structured Cabling*.

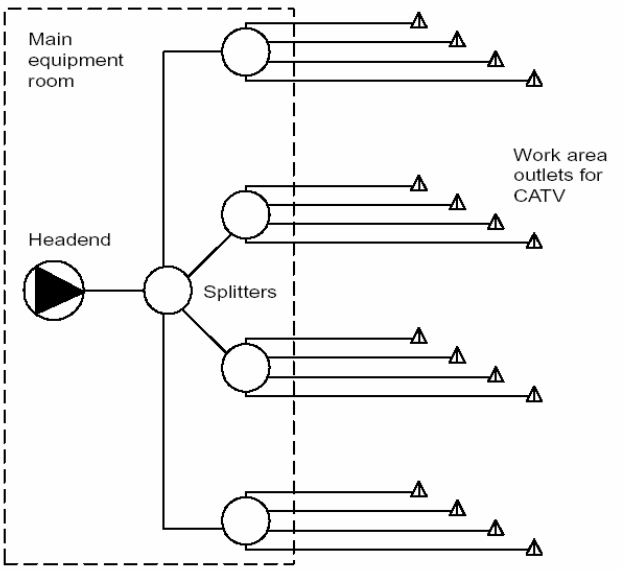
4.2 System Topology[135]

A. For small buildings use a "home run design" or star topology as shown in Figure D5030-3.

[135] Refer to Chapter 22 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

1. Provide a homerun drop cable run from each work area outlet to the entrance telecommunications room.
2. LANL will connect the telecommunications room to an entrance trunk cable from the LABNET headend.
3. LANL will provide an amplifier to boost the signal if needed.
4. The system will include a network of directional couplers (splitters) or taps to distribute the signal to the homerun drop cables.

Figure D5030-3: CATV Homerun Design[136]

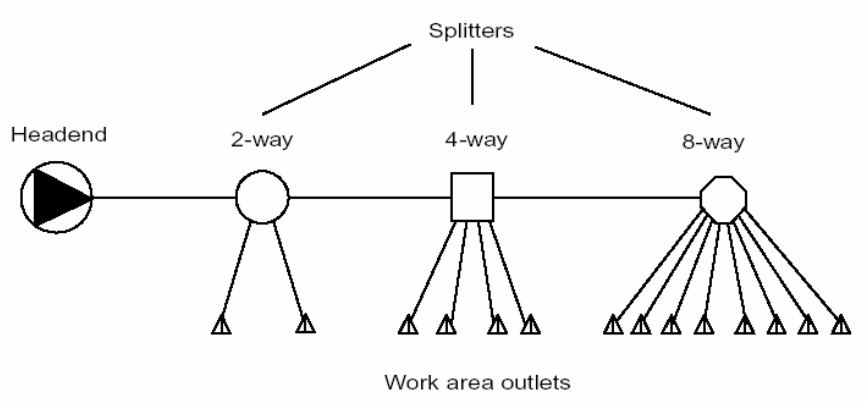


B. For large buildings use a "loop-thru" design as shown in Figure D5030-4.

1. Provide a trunk cable run through the building, typically in the telecommunications cable tray, with GFE taps installed wherever they are needed.
2. Provide drop cables run from the directional couplers (splitters) to the work area outlets.
3. LANL will connect the telecommunications room to an entrance trunk cable from the LABNET headend.
4. LANL will provide an amplifier to boost the signal if needed.

[136] Refer to Figure 22.1 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

Figure D5030-4: CATV Loop-Thru Design[137]



C. Coordinate system topology with the LANL Telecommunications Group.

4.3 Work Area Outlets/Connectors

A. Provide work area television outlets at the following locations:

1. Conference rooms
2. Training rooms
3. Division director offices
4. Group leader offices
5. Other locations to meet the Users' functional and operational requirements.

B. Locate a duplex convenience receptacle outlet adjacent to each television outlet. Coordinate outlet locations with location of television sets.

C. Outlet will consist of a plastic faceplate with one type "F" self-terminating coaxial cable connector that automatically puts 75 ohm load on cable run when cable is disconnected.

D. Coordinate outlet locations with furniture arrangements.

E. Install GFE crimp-on type coaxial cable connectors.

4.4 Television System Raceways

A. Design raceway systems for television system coaxial cables to meet the requirements for telecommunications cables.

B. Television coaxial cables may be installed in telecommunications cable trays.

[137] Refer to Figure 22.2 in the BICSI *Telecommunications Distribution Methods Manual*, Ninth Edition.

4.5 Coaxial Cable (GFE)[138]

A. Coaxial cable is UL listed as type CATVP for use in ducts, plenums, and air handling spaces.

B. Trunk cable: Type RG-11, 500 series, or 750 series cable, diameters are approximately 0.45, 0.50 or 0.75 inches accordingly.

C. Drop cable: [135] Type RG-6; cable diameter is approximately 0.25 inches.

5.0 UNCLEARED PERSONNEL WARNING LIGHT SYSTEM

5.1 General

A. Design a warning light system in corridors of the secure parts of LANL facilities to alert and remind building occupants of the presence of un-cleared or inadequately cleared visitors under escort in the area.[139]

B. Programmatic requirements may necessitate warning lights in additional spaces such as large computer rooms or large laboratory spaces that are not associated with corridors.

C. [Refer to LANL Specification Section 28 1355, *Uncleared Personnel Warning Light System* for materials and installation requirements. (This section is being developed.)]

5.2 System Design

A. Locate warning lights so they will be visible from all parts of every corridor in the secure parts of facilities; place warning lights not more than 15 ft from the end of the corridor with a separation not greater than 100 ft between lights. If there is an interruption of the concentrated viewing path, such as a fire door, an elevation change, or any other obstruction, treat the area as a separate corridor.[140]

B. Use NRTL-listed synchronized[141] xenon strobe lights with blue lens.

C. Provide labeled system control switches with indicator lamps at locations such as group offices or reception desks.

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138 Cable information based on data from the LANL Telecommunications Group.

139 Uncleared personnel warning light systems are effectively used in many LANL facilities for the purposes indicated.

140 Same spacing criteria used for uncleared personnel warning lights as for fire alarm visible alarm appliances in NFPA 72 4-4.4.2.2.

141 Testing has shown that high flash rates of high intensity strobe lights can pose a potential risk of seizure to people with photosensitive epilepsy. To reduce this risk, more than two visible appliances are not permitted in any field of view unless they are separated by at least 55 ft or unless their flashes are synchronized.

6.0 FIRE ALARM SYSTEM (SUPERSEDED WHEN THIS MATERIAL APPEARS IN ESM CHAPTER 2, REV 2 OR LATER)

6.1 General

A. Design a fire alarm system[142] in every building or structure of such size, arrangement, or occupancy that a fire itself might not provide adequate occupant warning.[143] Provide a fire alarm system if required by the *International Building Code*, NFPA 101–*Life Safety Code*, or LANL LIR 402-910-01 *LANL Fire Protection Program* based on the occupancy classification. Coordinate fire alarm system selection with the LANL Fire Protection Group.

B. Design fire alarm system to meet the applicable requirements of the following codes and standards and this Chapter of the LANL Engineering Manual:

1. NFPA 72, *National Fire Alarm Code.*
2. NFPA 70, *National Electrical Code.*
3. NFPA 101, *Life Safety Code.*
4. NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems.*
5. ASME A17.1, *Safety Code for Elevators and Escalators*
6. ASME A17.3, *Safety Code for Existing Elevators and Escalators*
7. NECA 305, *Standard for Fire Alarm System Job Practices* (ANSI).

C. Use the materials and installation methods described in the following LANL Construction Specification

1. Section 28 3100, *Fire Detection and Alarm* (Use for all new systems.)
2. Section 28 3125, *Additions to Existing Fire Alarm System*. (To be developed.)

D. For new or extensively renovated facilities provide addressable analog fire alarm systems.[144]

E. For additions or modifications to existing systems consult with the LANL Fire Protection Group to ascertain the appropriate alarm system technology to use. This will determine the arrangement of the system and the features that must be specified for the control panel alarm initiating devices, notification appliances, and accessory equipment.

F. Provide fire alarm systems with the following NRTL-listed fire alarm components as required by NFPA 72 and as necessary for a complete system:

1. Fire alarm control panel (FACP) to initiate sequences of operation for fire detection, notification, building system control, and fire suppression functions.

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142 A fire alarm system provides a reasonable level of safety by reducing the probability of injury and loss of life from fire, smoke, and heat in buildings by providing detection, suppression, and notification functions.

143 This fundamental requirement for occupant notification is from clause 4.5.4 of NFPA 101, 2000 Edition,.

144 The LANL Fire Protection Group has standardized on addressable systems for all new installations due to the low-initial cost, high capability, inherent communications, and ease of future component addition provided by such systems.

2. Conduit and wiring to connect the FACP to alarm initiating devices, notification appliances and auxiliary equipment.
3. Manual fire alarm station at each exit from each floor.[145]
4. Area smoke or thermal detectors where required by any NFPA code or standard, the *International Building Code*, or ASME A17.1. Note that with the exception of special facilities such as computer rooms, area smoke or thermal detectors are not required in areas that are protected with automatic sprinkler systems.
5. Duct smoke detectors and air handling systems shutdown relays where required by NFPA 90A and NFPA 72.
6. Connections to sprinkler waterflow alarm switches.
7. Connections to sprinkler system control valve and pressure supervisory devices.
8. Sounder and synchronized[141] signal strobe combination notification appliances.
9. Elevator recall/shunt relays (if the building has an elevator) as required by ASME A17.1.
10. Battery standby capable of operating the fire alarm system under maximum quiescent load (system functioning in a non-alarm condition with supervisory and trouble signals operating) for 24 hours, and at the end of that period operating all alarm notification appliances for not less than 10 minutes.[146]
11. Digital alarm communicator transmitter (DACT) to sent point-identified alarm, supervisory, and trouble signals to the LANL Central Station.
12. Conduit and GFE cable from the FACP to building's main telecommunications room.
13. Surge protection for line power circuits serving the fire alarm system.
14. Surge protection for initiation, notification, and signaling circuits that extend beyond the building or are otherwise exposed to lightning.

G. In general, each building that warrants a fire alarm system shall have its own fire alarm control panel.[147]

H. Digital alarm communicator transmitter (DACT) reporting format to the LANL Central Station shall be "Contact ID" capable of encoding specific point identification.[148]

6.2 Functional Requirements for Addressable Systems

A. The system shall identify any off normal condition and log each condition into the system database as an event.

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[145] Requirement for manually actuated initiating devices in part 2-8 of NFPA 72-1999 overrides any exceptions that may be provided in NFPA 101.

[146] The LANL Fire Protection Group augmented the battery standby capability requirement in clause 1-5.2.6 of NFPA 72-1999.

[147] The connection of several satellite buildings to a single FACP increases system complexity, exposes initiating and alarm circuits to lightning, and potentially leaves the satellite buildings without fire alarm due to events in the main building.

[148] The LANL Fire Protection Group has standardized on the "Contact ID" reporting format because it is capable of transmitting initiating device level alarm information to the Central Station.

1. The system shall automatically display on the control panel the first event of the highest priority by type. The priorities and types shall include alarm, supervisory, and trouble.
2. The system shall have a queue operation, and shall not require event acknowledgment by the system operator. The system shall have a labeled color coded indicator for each type of event.
3. The user shall be able to review each event by selecting scrolling keys.
4. New alarm, supervisory, or trouble events shall sound a silenceable audible signal at the control panel.

B. Operation of any alarm-initiating device shall automatically:

1. Update the control/display as described above.
2. Sound all alarm signals throughout the building. The fire alarm evacuation tone shall be the ANSI S3.41, *Audible Emergency Evacuation Signal* three-pulse temporal pattern.[149]
3. Turn on all strobe lights throughout the building.
4. Visually and audibly annunciate the alarm condition at the fire alarm control panel.
5. Operate the alarm relay and initiate the transmission of a point-identified alarm signal to the LANL central station over a digital alarm communicator system.
6. Operate control relay(s) to shut down HVAC units serving the floor of alarm initiation.
7. If there is an elevator, operate control relay(s) to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the LANL Fire Protection Group.
8. Shut down power to elevator equipment before sprinkler operation in the elevator equipment room.
9. Operate other auxiliary devices as required.

C. Activation of a supervisory signal-initiating device shall:

1. Update the control/display as described above.
2. Visually and audibly annunciate the supervisory condition at the fire alarm control panel.
3. Operate the supervisory relay and initiate the transmission of a supervisory signal to the LANL Central Station over a digital alarm communicator system.

D. The fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or derangement of system wiring and shorts across alarm horn/strobe wiring shall automatically:

1. Update the control/display as described above.
2. Operate the trouble relay contacts to initiate the transmission of a trouble signal to the LANL central station over a digital alarm communicator system.
3. Visually and audibly annunciate a general trouble condition, on the FACP. The visual indication shall remain on until the trouble condition is repaired.

[149] Refer to §3-8.4.1.2.1 in NFPA 72-1999.

6.3 System Design and Documentation

A. Fire alarm systems shall be both designed and installed by fire alarm contractors that are experienced in their proper design, application, installation, and testing.[150]

B. Design organizations (e.g. Architect/Engineer firms, Facility Managers, etc.) will provide performance specifications based on LANL Master Specification Section 28 3100 [or 28 3125].

C. The fire alarm contractor will provide the services of a qualified fire alarm designer factory trained for the FACP to be installed on the project. The fire alarm designer shall assure the completeness and correctness of the fire alarm system design by preparing and submitting the following for review by the LANL Fire Protection Group:

1. Shop drawings of the FACP indicating location of components, interconnection of components and connections to alarm initiating, indicating, and auxiliary circuits.
2. Fire alarm riser diagram showing new and existing alarm initiation circuits, alarm appliance circuits, input/output functions, and communications connections.[151] Show all new and existing fire alarm devices and the corresponding room numbers.[154] Refer to Standard Drawing ST-D5030-2.
3. System input/output matrix showing the system actions in response to alarm, supervisory, and trouble conditions.[151] Refer to Standard Drawing ST-D5030-2.
4. Floor plan drawings of fire alarm layout, conduit, and wiring. Show location of all fire alarm appliances, conduit layout, quantity, and type of wires in each conduit, and interface with other systems for functions such as central station signaling, fan shutdown, damper operation, and elevator recall.[154]
5. Terminal-to-terminal field wiring diagrams for alarm initiating, indicating and auxiliary circuits; detail the interfaces with other systems; indicate labeling of each fire alarm system conductor. [154]
6. Conductor size calculations for each alarm initiating, indicating, and auxiliary circuit; limit voltage drops so that they do not exceed the FACP manufacturer's limitations for the most remote device on each circuit.[152]
7. Battery load calculations for the FACP and any remote power supply panels and selection of proper battery size.[146]
8. Audible alarm signal calculations for all spaces demonstrating that the design complies with NFPA 72 requirements of alarm signal a minimum of 15 dB above ambient at all locations, but not over 120 dBA at any location.[153]
9. Selection of initiating, indicating, and auxiliary devices compatible with the FACP.
10. Record as-built drawings showing all changes to design documents.[154]

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150 Refer to §1-5.1.3 in NFPA 72-2002.
151 The fire alarm riser diagram and associated input-output matrix show the functional interconnections of initiating devices, notification appliances, and controlled systems.
152 Lesson-learned from several previous fire alarm projects.
153 Refer to part 4-3 of NFPA 72-1999.
154 Accurate design and as-built documentation facilitates maintenance and future system modifications.

6.4 Installation

A. Install fire alarm systems in accordance with NECA 305, *Standard for Fire Alarm System Job Practices* (ANSI). [5]

B. The FACP DACT will be connected by the LANL Telecommunications Group as follows:

1. *In new facilities and where possible in existing facilities, the DACT will be connected to two separate dedicated analog telephone lines (numbers) on the public switched network.*
2. *Where two dedicated lines are not available, the LANL Fire Protection AHA **may** grant special permission to use existing voice grade DTMF analog telephone lines within the protected premises. Preference is low-use telephone lines such as lobby, conference room or break room numbers. Lines that carry data transmission such as FAX machines or data modems cannot be used. Personal desktop telephone numbers will only be used if no other low use lines are available. Lines that may be required for emergency use will not be used.*
3. *Each connection will be made to a loop start telephone circuit that provides a timed release disconnect.*
4. *For non-dedicated lines, two RJ31X jacks will be installed in the FACP. One will be labeled "PRIMARY" and the other "SECONDARY". For the "PRIMARY" jack cable pair 1 (blue) will be connected to the primary line and pair 2 (orange) to the premise telephone (if any). For the "SECONDARY" jack cable pair 3 (green) will be connected to the secondary line and pair 4 (brown) to the premise telephone (if any).*

6.5 Acceptance Testing and Inspection

A. Test installed fire alarm system in accordance with NFPA 72.[155] Use an inspection and testing form that is acceptable to the AHJ.[156]

B. Notify the LANL authority having jurisdiction (AHJ) before conducting acceptance testing and inspection. Furnish a written statement to the AHJ stating that the system has been installed in accordance with approved plans and tested in accordance with the manufacturer's specifications and the appropriate NFPA requirements.[157]

C. Provide "record of completion" upon successful acceptance test and inspection.[158]

7.0 ADMINISTRATIVE ACCESS CONTROL SYSTEM

7.1 General

A. Design administrative access control (badge reader) system as described in this section and as required by the Users' programmatic needs. Coordinate requirements with the LANL Telecommunications Group.

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155 Refer to Chapter 7 in NFPA 72-1999.
156 Refer to §7-5 in NFPA 72-1999.
157 Refer to §1-6.1.2 in NFPA 72-1999.
158 Refer to §1-6.1 in NFPA 72-1999.

B. Provide an administrative access control system described under this heading in any of the following situations:[159]

1. The building or system exterior is located in a "public domain" and the interior is classified as a "property protection area." *(A "property protection area" is intended to protect against damage, destruction, or theft of Government property. A "property protection area" is defined as one in which personnel are not required to have a clearance or be escorted but must pass through a guard or access control point. A "public domain" is an area where uncleared persons have unescorted access and uncontrolled access. This applies even if it is on Government property.)*
2. The building or system exterior located in a "limited area" or above, and the interior is classified as a "limited area" or above. *(A "limited area" is defined as one in which personnel access is limited to persons possessing a final, Government-issued security clearance or are under escort by an individual possessing final, Government-issued security clearance. A "limited area", through physical barriers and controlled access, is intended to protect classified material or Category III SNM.)*
3. The User requires automatic entrance and exit control and logging for a room or area.
4. Doors controlled by administrative access control systems typically include:
   - *Each exterior door or set of doors except at vestibules install the access controls on the interior door or set of doors.*
   - *Electrical room doors.*
   - *Mechanical room doors.*
   - *Telecommunications room doors.*
   - *Server room doors.*

C. The LANL Telecommunications Group will furnish and install badge readers, power supplies, and control equipment.

D. Raceways, boxes, cables, and electric strikes or panic bars will be furnished and installed by the construction contractor; refer to Section 28 1321, *Administrative Access Control System Rough-In*.

E. The system controller will be furnished and installed by the LANL Telecommunications Group. Wiring from the controller to the terminal box in the telecommunications room will be furnished and installed by the LANL Telecommunications Group.

F. Provide electric door strikes and electric crash bars that will be compatible with the administrative access control system.

1. Operating voltage: 24 VDC.
2. Door strike current: 0.3 amperes maximum.
3. Crash bar current: 0.5 amperes maximum.

G. *Time and funding will be necessary for the installation of access control system controller, performance testing, and field quality assurance activities by the LANL Telecommunications*

[159] Criteria provided by the LANL Security Systems Group.

Group. The Project should obtain a definitive cost estimate and schedule from the LANL Telecommunications Group.

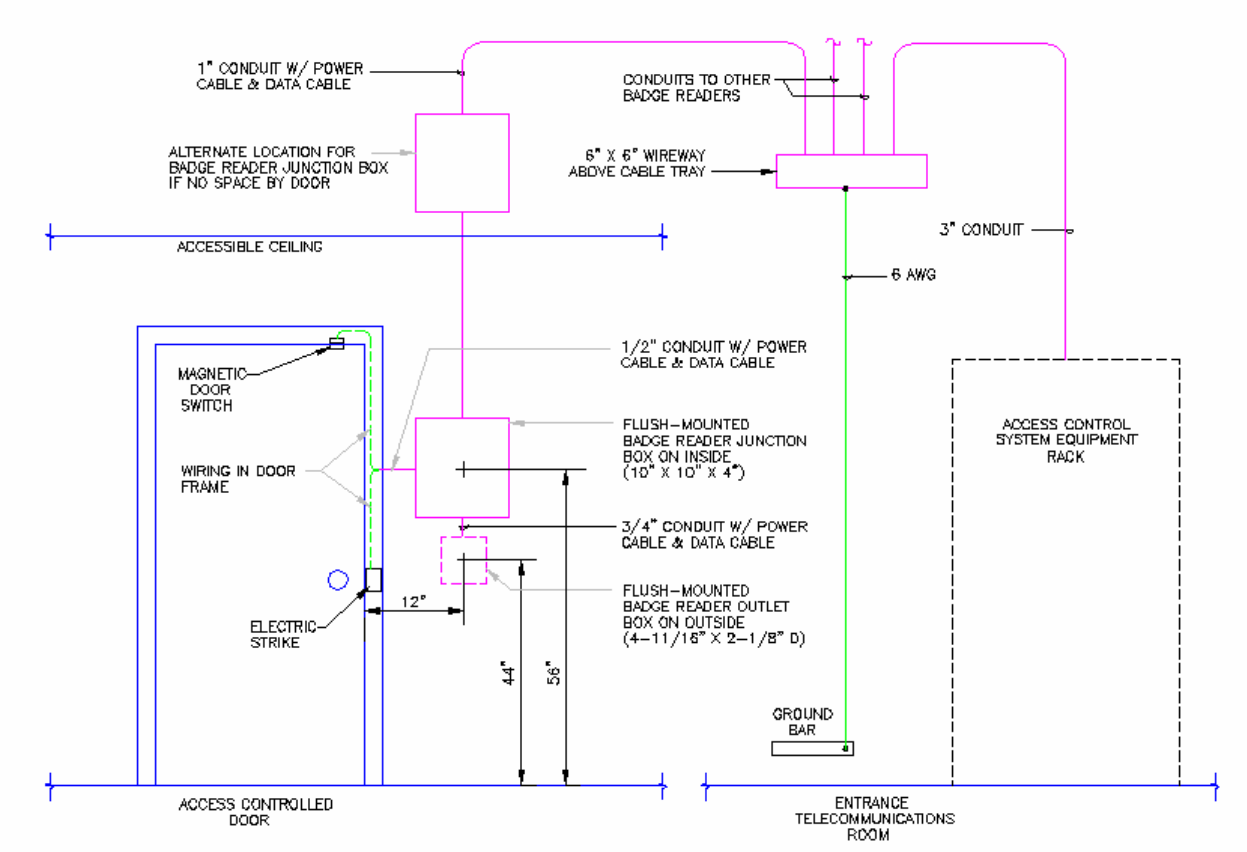
H. Refer to LANL Construction Specification Section 28 1321, *Administrative Access Control System Rough-In* for materials and installation requirements.

7.2 System Design

A. Provide a suitably sized wireway in the entrance telecommunications room.

B. Provide a 3-inch conduit from the wireway to the access control system equipment rack.

Figure D5030-5 Typical Administrative Badge Reader System



C. Distribute and terminate 12 and/or 24 VDC power and data cables from the wireway in the telecommunications room to each badge reader, electric strike, and door switch. Refer to Figure D5030-5 for typical locations and connections of badge reader system components.

D. Distribute and terminate 12 and/or 24 VDC power and data cables from the wireway in the telecommunications room to each badge reader, electric strike, and door switch. Refer to Figure D5030-5 for typical locations and connections of badge reader system components.

1. Install power and data cables from the wireway in the telecommunications room to a badge reader junction box at each controlled-access door.

2. From the badge reader junction box install power cables to the badge reader outlet box and the door electric strike.
3. From the badge reader junction box install data cables to the badge reader outlet box and the door contacts.

E. Design raceway systems for access control system cables that meet the requirements for telecommunications cables. Provide an individual 1" conduit from each badge reader junction box to the wireway in the telecommunications room; refer to Figure D5030-5.

8.0 PHYSICAL SECURITY SYSTEM (PSS) (SUPERSEDED BY ESM CHAPTER 9 WHEN ISSUED)

Preface

Unless otherwise directed and formally documented by S-Division' Security Plans and Programs Group (S-1), LANL's Security Systems Group (S-3) will provide a physical security system (PSS) pursuant to DOE Order 470.1, DOE Manual 473.1-1, and DOE Manual 471.2-1C. These DOE Manuals and Order are incorporated into S-Division's Site Safeguards and Security Plan (SSSP) and are based upon the Department of Energy's Design Basis Threat. Where there is room for interpretation of the Manual or Orders, S-3 will pursue a conservative approach in our application of protection strategies. These strategies have been consistently validated by DOE's Office of Assessment.

Prior to all LANL PSS certifications, S-3 will conduct formal Performance Testing activities pursuant to the aforementioned DOE Manual and Orders.

The PSS described herein, then, will provide an overall electrical infrastructure necessary to meet the requirements delineated in the Orders and Manuals. LANL's Security Systems Group (S-3) maintains final approval authority of all Laboratory PSS installations and must be engaged from the onset of all PSS activities.

8.1 General

A. Design physical security system (PSS) as described in this section and as augmented by the LANL Security Systems Group.[160]

B. Coordinate PSS design and installation requirements with the LANL Security Plans and Programs Group. *The LANL Security Plans and Programs Group will assign a Security and Safeguards Division representative to facilitate activities between the LANL Security Integration Group, the LANL Security Systems Group, and the LANL Security Support Group. As necessary, LANL security force activities will be integrated with the project.*

1. *For new facilities, the PSS objectives will be defined and the PSS designed and evaluated.*

[160] Physical Security System (PSS) design is a graded process. It includes determining the PSS objectives, designing the System with inherent detection, delay and response constituents, and then evaluating the design with regards to meeting the objectives. Physical constituents of an adequate PSS design include fencing, gates, barriers, grading, drainage, and roads, lighting, security barrier penetrations, such as utility and sound barriers, CCTV systems, intrusion detection systems, and entry control points. Special nuclear material protection has further design requirements.

2. *For existing facilities, the PSS objectives will be re-examined to ensure adequacy and then the PSS designed and evaluated.*
3. *In all cases, performance testing will be accomplished prior to final acceptance and certification.*

C. Interior Intrusion Detection (IIDS) and Automated Access Control Systems (AACS) will include one or more of the following sub-systems; coordinate project-specific requirements with the LANL Security Systems Group:

1. *General*
   - *Laboratory field panels (LFPs).*
   - *Copper and fiber optic cables for power, control, and data.*
2. *Automated Access Control Systems (ACCS) with*
   - *Door access control systems with badge readers, biometric units, and door hardware (strikes and latches) with key overrides.*
   - *Turnstile access control systems with badge readers and/or biometric units. Turnstile egress may be accomplished with a push button or badge reader.*
3. *Interior intrusion detection systems (IIDS) with:*
   - *Volumetric, perimeter, and/or point contact detectors*
   - *Door sensor switches*
   - *Closed-circuit television (CCTV).*

D. PSS control electronics to include biometric units, badge readers, door sensor switches, volumetric detectors, and CCTV equipment will be furnished and installed by the LANL Security Systems Group. Contractor will install all electrical infrastructures (conduit, cable, boxes, fittings, etc) per Project drawings bearing approval from LANL's Security Systems Group Design Group.

E. *Time and funding will be necessary for the installation of PSS devices and electronics, performance testing, and field quality assurance activities by the LANL Security Systems Group. The Project should obtain a definitive cost estimate and schedule from the LANL Security Systems Group.*

1. *The installation of PSS field devices will begin <u>after</u> beneficial occupancy.*
2. *Performance testing and field quality assurance activities will begin <u>after</u> the installation of PSS field devices is completed.*

F. Use materials and installation methods described in LANL Construction Specification Section 28 0528, *Pathways for Electronic Security*.

8.2 Conduit

A. Construction Contractor will install PSS wiring in conduit system. Coordinate design of the conduit system with the LANL Security Systems Group.

B. Design conduit runs with no more than 100 feet between pull points.[161]

C. Design conduit runs with no more than 180-degrees of bends between pull points. Install a pull box at any reverse bend.[162]

D. For conduits 2 inches and smaller the inside radius of conduit bends must not be less than 6 times the internal diameter of the conduit.[163] For conduits larger than 2 inches the inside radius of conduit bends must not be less than 10 times the internal diameter of the conduit.

E. Select conduit sizes on the following basis:

- Less than 50 ft between pulling points and only one bend: 40 percent fill.
- More than 50 ft between pulling points or two 90-degree bends: 31 percent[164] fill.
- Minimum size: 1-inch unless specified otherwise

8.3 Boxes

A. Coordinate locations of all PSS boxes with the LANL Security Systems Group. *This coordination will result in a signed document verifying the number and location of each box.*

B. Construction Contractor will furnish and install 4-11/16 square 2-1/8 inch deep boxes[165] for badge reader, biometric, and volumetric detector outlets.

C. LANL will furnish specialty PSS boxes as GFE[166] for installation by the Construction Contractor:

- *10" x 10" x 4" junction boxes.*
- *60" wide x 60" high x 12" deep or 36" wide x 36" high x 12" deep Laboratory Field Panel (LFP) enclosures, depending on system requirements.*
- *4" x 4" x 4" boxes for access/secure switches and pushbuttons.*
- *Mounting brackets for badge readers and biometric units.*

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161 Requirement in §4.4.2.2 of TIA/EIA-569-A is extended to security system cables because they are similar to telecommunications cables.

162 Requirement in §4.4.2.3.1 of TIA/EIA-569-A is extended to security system cables because they are similar to telecommunications cables.

163 Requirement in §4.4.2.3.2 of TIA/EIA-569-A is extended to security system cables because they are similar to telecommunications cables.

164 Security system cables are much more fragile than standard building wire. FPN No, 1 to Table 1 in NEC Chapter 9 states that for certain conditions a lesser conduit fill should be considered. Note 2 to Table 4.4-1 in TIA/EIA-569-A states that the number of cables that can be installed in a conduit is limited by the allowed maximum pulling tension of the cables.

165 Outlet box requirements from the LANL Security Systems Group.

166 Specialty box information from the LANL Security Systems Group.

8.4 Cables[167]

A. The LANL Security Systems Group will furnish as GFE the copper and fiber optic cables for data and control for field devices. The Construction Contractor will provide and install AC power branch circuit(s) from local panelboard to LFP(s). Refer to section titled 'Field Panel Installation'.

B. Construction Contractor will install GFE control and data cables in accordance with approved LANL Security Systems Group design.

C. Construction Contractor will label each cable at both ends with sufficient information to distinguish individual cables. LANL Security Systems Group will apply final identification labels to all security system cables.

D. The LANL Security Systems Group will connect the control and data cables.

8.5 Security Service Entrance[168]

A. For PSS not protecting Category I or II SNM provide one security service entrance pathway from the point of connection to the telecommunications network (manhole, pedestal, etc.) into the entrance telecommunications room. The pathway may use the telecommunications service pathway to the building.

B. For PSS protecting Category I or II SNM provide two separate security service entrance pathways from the point of connection to the telecommunications network (manhole, pedestal, etc.) into the entrance telecommunications room.[169]

1. One or both of the pathways may use the telecommunications service pathway to the building if the physical separation requirement is met.
2. The security service entrance pathways must have a wall-to-wall separation of not less than 16 inches to reduce the possibility of simultaneous disruption.

C. The LANL Telecommunications Group will furnish, install, and terminate the security service entrance cables.

D. Use materials and installation methods described in LANL Construction Specification Section 33 7119, *Underground Electrical Ducts and Manholes*.

8.6 Field Panel Installation[170]

A. Design installation of GFE Laboratory Field Panel (LFP) enclosures in the entrance telecommunications room and at other locations designated by the LANL Security Systems Group. Coordinate final LFP location within the telecommunications room with the LANL Security Systems Group and the LANL Telecommunications Group.

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167 Security system cable information provided by LANL Security Systems Group.
168 Security system service entrance information provided by LANL Security Systems Group.
169 Refer to Chapter 7 in DOE M5632.1.C-1. Defense in depth for Category I and II SNM requires redundant, independently routed communications paths to avoid a single-point failure.
170 Security system LFP information provided by LANL Security Systems Group.

B. Provide a dedicated space that is 6 feet wide, 8 feet high, and 14 inches deep for each LFP.

C. Construction Contractor will furnish and install an 8" x 8" x 72" NEMA 12 feed-through type wireway centered at 9' AFF above LFP.

D. Construction Contractor will furnish and install two, 20-ampere, 120-volt, double-duplex receptacle outlets on the lower inside right side of the LFP enclosure. Serve each LFP outlet by a dedicated 20-ampere branch circuit.

E. Refer to PSS installation detail drawings available from the LANL Security Systems Group.

8.7 Rough-in for PSS Field Devices and Junction Boxes[171]

A. Refer to LANL Construction Specification Section 28 0528, *Pathways for Electronic Security*, for materials and installation methods.

B. Refer to PSS installation detail drawings available from the LANL Security Systems Group.

[171] PSS rough-in information provided by LANL Security Systems Group.